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CALIFORNIA SEWAGE WORKS JOURNAL

VOL. I • 1928 • No. 1

Proceedings of the
First Annual Meeting
of the
California Sewage Works Association
held at
San Bernardino, October 9-12, 1928
and
Special Articles

OFFICIAL PUBLICATION OF THE
CALIFORNIA SEWAGE WORKS ASSOCIATION

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CALIFORNIA SEWAGE WORKS JOURNAL

Address all communications to the Secretary

This Journal, together with the Journal of the Federation of Sewage Works Associations, free to members. Extra copies, $1.00

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Printed by

WESTERN CONSTRUCTION NEWS, Inc.
114 Sansome Street, San Francisco, California

CALIFORNIA SEWAGE WORKS JOURNAL

Published by

CALIFORNIA SEWAGE WORKS ASSOCIATION

VOL. 1 1928 No. 1

CONTENTS

Officers and Committees - - - - - - - - - - - - 2
Application for Membership - - - - - - - - - - - 3
Ballot on Program for 1929 - - - - - - - - - - - 4
Objects of the California Sewage Works Association—C. G. Gillespie 5
Program—San Bernardino Meeting October 9-12, 1928 - - - 12
Minutes—San Bernardino Meeting, October 9-12, 1928 - - 14
Relation of California Sewage Works Association to League of Municipalities—Wm. J. Locke - - - - - - - - - 21
Papers Read at the San Bernardino Meeting *(with abstracted discussion)*
Water Tight Sewer Joints—Herman P. Cortelyou - - 26
Cleaning Sewers—F. A. Batty - - - - - - - - - 33
Standardizing Sewer Pipe—E. L. Phillips - - - - - 40
Report of Committee on Trade Wastes and Sewage Disposal—W. T. Knowlton - - - - - - - - - 42
Financing Sewer Maintenance—Leon B. Reynolds - - 46
Know Your Sewage—C. C. Kennedy - - - - - - 68
Sludge Digestion—C. G. Gillespie - - - - - - - 75
Odor Control by Chlorination—R. F. Goudey - - - 87
Trials and Tribulations of a Sewage Works Operator—A. W. Wyman - - - - - - - - - - - - 102
Outline of Tests for Settleable Solids, Free Chlorine, pH, and Relative Stability—E. A. Reinke - - - - - - 112
Description of Plants Visited by Members of California Sewage Works Association, October 9-12, 1928
A Brief Description of the Sewerage Systems and Treatment Plants at Lake Arrowhead—M. Ellinger - - - 116
San Bernardino Sewage Disposal in a City Park - - - 121
Pomona Sewage Disposal Works—Alva J. Smith - - 124
Joint Treatment Plant of Los Angeles County Sanitation Districts—A. K. Warren - - - - - - - - - 125
Special Article
The Prevention of Odor Nuisance in the Disposal of Creamery Wastes by Treatment with Chlorine Preliminary to Broad Irrigation—E. A. Reinke - - - - - - - - - - 128
List of Members - - - - - - - - - - - - - - 133
Constitution and By-Laws - - - - - - - - - - - 135

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Addresses will be found in List of Members on page 133

California Sewage Works Journal

The California Sewage Works Association is not responsible, as a body, for the supposed facts and opinions advanced in any of the papers, discussions, or articles published in its Journal. Discussion of all papers is invited.

VOL. I 1928 No. 1

Objects of the California Sewage Works Association

By C. G. GILLESPIE*

> *The object of this Association shall be the advancement of the fundamental and practical knowledge concerning the nature, collection, treatment, and disposal of sewage and industrial wastes, and the design, construction, operation and management of sewage works in California, through the interchange, between members of the Association and with others, of information, experience, and opinion relating thereto.*—Article III, Constitution, C.S.W.A.

EVENTS LEADING UP TO ORGANIZATION OF THE CALIFORNIA SEWAGE WORKS ASSOCIATION

The genesis of the California Sewage Works Association goes back to 1923, when the Bureau of Sanitary Engineering conducted about twenty members of the California Water Works Association, then meeting in Fresno, to see several sewage treatment plants surrounding that city. The trip proved very instructive, but was never tried again, principally because of interference with the Water Works Association program.

Within the next few years the Proceedings of the New Jersey Sewage Disposal Association falling into the hands of a few of us, made a deep impression that their association was a fountain-head of hitherto unrevealed information of great usefulness in operating sewage disposal works, and their proceedings also

*Chief, Bureau of Sanitary Engineering, State Department of Public Health, Berkeley, Calif.

gave the advance results of the pioneer research being carried on by the State under Dr. Wm. Rudolfs, antedating their published appearance by over a year.

Then during the fall and summer of 1927 a number of engineers and research workers with a few operators, throughout the East, were feeling for an outlet for the results of research, cost data, etc., being obtained in several other places outside of New Jersey. The outcome of their enterprise was the foundation of a Federation of Sewage Works Associations, whose principal object for the present is to furnish an outlet for papers, particularly on sewage research.

As soon as the success of the Federation was assured, the California State Department of Public Health, through myself, called a meeting to sound out the propriety of organizing an association of operators, engineers, and any one else interested in sewers or sewage disposal in California. This meeting was timed to allow the members of the California Water Works Association, meeting in San Francisco June 11 and following, to be present. Fifty-one men representative of all parts of the State, and including such guests as George W. Fuller, consulting engineer, New York; Abel Wolman, chief engineer, Maryland State Board of Health, and E. G. Eggert, assistant engineer, Texas State Board of Health were present. Both Maryland and Texas have similar associations. After a couple of hours of enthusiastic discussion the meeting went farther than was anticipated. It voted to form an association, elected an organizing committee composed of Messrs. Warren, Jensen, Steward, Schuyler, and Gillespie, voted to request membership of the Association in the Federation, and fixed dues at $2 per year, without admission. A. K. Warren, Los Angeles, was elected chairman of the organizing committee, and working committees were forthwith appointed as follows:

Constitution and By-Laws, and Nominating Committee—W. G. Knox, Santa Ana; A. M. Rawn, Los Angeles; Leon B. Reynolds, Stanford University; Fred Post, Lodi, and C. C. Kennedy, San Francisco, chairman.

Membership Committee—All members with W. T. Knowlton, Los Angeles, chairman.

Program Committee—Alva J. Smith, Los Angeles; W. C. Earle, Pasadena; J. J. Jessup, Los Angeles;

Harold Young, Los Angeles county, and R. F. Goudey, resident engineer, State Department of Public Health, Los Angeles, as chairman.

As representatives of the Association on the board of control of the Federation, the organizing committee appointed W. T. Knowlton and C. C. Kennedy.

Before adjournment the meeting voted to hold its first annual meeting or convention in San Bernardino, October 9-12, in conjunction with the League of California Municipalities Convention.

From that point on it has been a matter of arranging the program for that meeting and carrying it out in the most satisfactory manner. The minutes, papers, and discussions tell the story from this point on.

A LOOK INTO THE FUTURE

Out of a most enthusiastic maiden meeting in San Bernardino, October 9-12, inclusive, the California Sewage Works Association is aspiring to a long life of usefulness to the citizens of this State. Its specialty, of course, is with anything that will make the net results of the collection and final disposal of sewage more easy, reliable, and economical as the years pass.

The necessity of sewage disposal as thought of today arises from neighborly justice or from rights enforceable in the courts. We shall soon think of it in terms of reliability, net economy, and compactness of plant, as an element of conservation of the land and industrial resources of the State. Within a century, moreover, we may come to think of it in terms of biologic necessity, and we shall find those peoples with high standards of sanitation and virile health alone fit to survive upon the earth.

The membership in the Association is essentially municipal, because sewers are without exception a municipal utility in this State. Membership, however, is open to anyone whose interest parallels that of the Association. At the present moment there are 117 members, segregated as follows: 44 city, county, and state engineers; 19 administrators, such as chairmen of sewer committees, inspectors, etc.; 18 consulting engineers; 17 in commercial enterprises; 11 operators and sewer superintendents; 4 laboratory and research technicians; and 4 unclassified.

We may as well recognize that the amount and calibre of sewage plant operations here in California, and for that matter throughout the country, is too out

of scale with engineering investment to represent good economics or a healthy condition for sanitation. Works capable of good results are not yielding the results anticipated in the design in the vast majority of cases, because of the inferiority of operating skill or personnel. Just as a matter of economics, cities would in many cases be better off to build less expensive works and operate them more efficiently, than under the present converse practice of building complicated works and then providing deficient operation.

It was this situation that induced the movers for the Association to call the meeting of organization. That situation must not be lost sight of in the complex viewpoints of the membership personnel.

The Association, through its conventions, conferences, and printed publications, is in reality the one and only clearing house here in California for sewerage and sewage disposal intelligence, comprising the experiences and ideas of our men who are responsible for sewage disposal or who engage in its research. Even now, every engineer and every operator and inventor has observations to his credit, or facts which properly planted elsewhere yield or would yield large returns. Scientific sewage research is established in spots elsewhere. It is now a prospect here. Unless its findings are broadcast, however, it will be a lifeless thing and information often priceless will lie hidden and unapplied if not for some such organization as this.

The influence of the Association may easily and properly extend beyond the realm of stimulation and enlightenment among operators into energizing any move that may put sewerage and sewage disposal on a higher plane; for example: the licensing of operators; more expert supervision and laboratory control of processes; measures for financing of operation expense; development of revenue from sewage and sludge; extension of research; standardizing specifications and manufactured commodities useful for sewers and disposal; stimulating the better keeping of operating records; promoting the civic pride in works, as by beautification and parking; and establishing uniformity in viewpoint to the many vexing problems and practices constantly arising, like the present one associated with industrial waste.

The movement here in California is just part of a

nation-wide similar effort in each State. The several State associations are in turn affiliated in a 'Federation' of Sewage Associations. Benefits accruing from the Federation immediately are its Journal, which is a high-class publication; and, in the course of a few years we will undoubtedly see national as well as state conventions.

As a means of preserving and distributing our own papers and discussions, Western Construction News of San Francisco has kindly made possible the printing of our proceedings. A part of these papers, however, will undoubtedly be chosen to appear in the Federation Journal.

It is auspicious that the Association has adopted a constitution and by-laws which has come in for some most favorable comment; and that the constitution provides for a rather large governing board. The first members elected are well distributed by locality and according to talent, to be representative of the membership. All the officers elected are deeply imbued with the purpose of laying the foundation for an earnest enterprising organization, capable of expansion to meet the problems of sewers and sewage disposal put up by the future. The serious-mindedness of the members who attended the San Bernardino meeting was indeed wholesome and was a good omen. It is that earnestness of spirit that we want to see preserved in the Association. It leads to studiousness, a square facing of the facts, interpretation without embellishment, and keeps us hewing to the line which in our case is a big part of a mighty noble purpose of giving our people a better degree of sanitation.

The make-up of program is obviously far-reaching in sustaining such an Association as this. The program of this year undoubtedly set a good pattern. It was well received. The realm of the Association, however, is wide, covering topics of design, construction, operation, research, manufacture, and finance of sewers themselves and of all manner of treatment tanks, filters, pumps, and even minor devices; each with an interesting story and each with valuable potential research. There is the very practical problem of securing greater local pride in works, methods of parking and beautification, and the unescapable problem of obtaining the wherewithal for operation. Offsetting this are the methods followed to realize

revenue from the sale of sludge and water, that appeal so rightly to a taxpayer. There must be contributions to the program on cost and efficiency, which the requirements of later years will stress more and more.

We have seen that programs can take the form of papers from simple to the complex, and from discussions to demonstrations, inspections, and entertainment. The sentiment of the membership at present appears to be for simple rather than technical papers. Nevertheless an intellectual advance requires technical papers. The program must satisfy a membership that cuts across engineers, operators, administrators, research workers, and representatives of the trades.

Thus there is no dearth of material for programs; but to produce a well-balanced program, always paving the way for some new advance in thought or practice and satisfying the membership always, is a delicate task.

The drives for membership and admission of members call for a realization that the composition of the membership is sure to fix the complexion of the Association for a long time. At present the bulk of it is made up of engineers in public employ, councilmen, and but a few operators. The widest field open to the usefulness of the Association is assuredly among the operators. It is that group that the originators of the idea here in California sought to reach. It would be unfortunate if our membership developed into one that was too strongly technical or too strongly commercial. Neither of these sources of membership, and including also the research workers, needs special encouragement to affiliate. The operators however, as a class, are apt to be slow to take advantage of the Association and it is to that group that everything should now be made to appeal.

It has been suggested that the Association can accomplish much in an engineering way through improving and standardizing specifications, especially on sewer joints and laying, and on standardizing the sizes and types of sanitary equipment. Regulation and standardization are obviously fine things, carried to a certain point, but let us see broadly and leave a wide open door for individual development and initiative.

This brings us to the subject of our relationship to other organizations, technical and trade. Though it is

true we are in a rather virgin field, the Association should studiously avoid trespass on ground occupied by others. In such fields of joint concern it will be well to adhere faithfully to a plan of joint discussion or action in formulating requirements of mutual concern.

In the matter of future meetings, there is a difference of thought as between one and two meetings a year. For the next few years, while the Association is not so widely known, it seems wise to place meetings in the sections of the State where there are likely additions to the membership; this for mutual benefit. It seems a safe course, therefore, to determine the frequency and place of meetings by the strength of local preference in the locality being considered for the meeting place. As yet, no decision has been reached regarding the next meeting, except that so far as the annual elective meetings are concerned, they should rotate between the two ends of the State. The next meeting will therefore be held in the northern or central part of the State.

The San Bernardino meeting was held in conjunction with the meeting of the League of California Municipalities, but there was more or less conflict and disruption of both programs as a result. It was noted also that in the exodus of officials from their respective cities at that time, there was a tendency to leave the sewer operator behind. There is therefore sound argument for meeting elsewhere than with the League in future. On the other hand, there is undenied benefit in a certain amount of affiliation with the League. These considerations remain to be harmonized. One suggestion offered is that our Association should contribute one or two exceptionally good papers to the League programs, but our own meeting to be held at a different time and place.

These 'out loud' thoughts have been indulged in for a double purpose, namely, to show the discussions and moves now made must be looked upon as the foundation stones of the future edifice; and they are intended to stimulate us to look on the Association as a vital thing that deserves the best constructive thought that each of its members can give. It is not as though there is a membership on one hand and a set of officers on another, but it is as though there is an intensely interested membership with a number of duly constituted 'listening posts' to translate ideas into action.

PROGRAM

First Annual Convention, California Sewage Works Association

San Bernardino, California, October 9-12, 1928

9:00 a.m.— **Tuesday, October 9**

Organization. Reports of committees, officers. Election of officers.

10:30 a.m.—Discussion—

'Standardizing Sewer Pipe', by E. L. Phillips, assistant engineer, sewer division, city of Los Angeles.

'Water-Tight Sewer Joints', by H. P. Cortelyou, construction engineer, engineering department, city of Los Angeles.

'Methods of Sewer Cleaning', by F. A. Batty, maintenance engineer, engineering department, city of Los Angeles.

12:00 a.m.—Luncheon. Open forum.

2:00 p.m.—

Joint meeting with the department of engineers, councilmen, and street superintendents of the League of California Municipalities.

'Report of Committee on Trade Waste and Sewage Disposal', by W. T. Knowlton, Metropolitan sewer division, engineering department, city of Los Angeles.

'Financing of Sewer Mantenance', by Leon B. Reynolds, professor of hydraulic and sanitary engineering, Stanford University.

'Know Your Sewage', by Clyde C. Kennedy, consulting engineer, San Francisco.

4:00 p.m.—

Inspection of San Bernardino sewage treatment plant under construction.

8:00 p.m.—

Barn dance with League of California Municipalities.

9:00 a.m.— **Wednesday, October 10**

'Sludge Digestion', by C. G. Gillespie, chief, Bureau of Sanitary Engineering, State Department of Public Health.

Address by Wm. J. Locke, secretary, League of California Municipalities.

'Odor Control by Chlorination', by R. F. Goudey, resident engineer, Los Angeles, State Department of Public Health.

12:00 a.m.—Luncheon. Question Box.

2:00 p.m.—

'Trials and Tribulations of Sewage Works Operators', by A. W. Wyman, superintendent, Pasadena sewage disposal plant.

2:30 p.m.—

Laboratory demonstrations and school. Demonstration of simple tests of measurement of settleable solids, free chlorine, hydrogen ion concentration, and relative stability. Instruction will be in charge of E. A. Reinke, assistant engineer, Bureau of Sanitary Engineering, State Department of Public Health. The purpose and method of each test will be explained during its demonstration.

Thursday, October 11—Field Day

9:15 a.m.—

Trip to Lake Arrowhead. Inspection of north sewage treatment plant.

12:30 p.m.—

Lunch at Lake Arrowhead. (Guests of Lake Arrowhead Company.)

1:30 p.m.—

Demonstraton of use of tools and discussion of processes of south sewage treatment plant at Arrowhead lake.

6:30 p.m.—

Banquet—League of California Municipalities.

Friday, October 12—Field Trip

8:00 a.m.—

Inspection of sewage treatment plants at Pomona, Pasadena, and Los Angeles County Sanitation Districts plant at Harbor City. Inspection also will be made of the pipe manufacturing plant of the Pacific Clay Products Co. at Santa Fe Springs, where the party will be guests of the Pacific Clay Products Co. at luncheon.

Party will break up at Harbor City about 4:00 p.m.

Minutes of First Annual Meeting of California Sewage Works Association

Held at American Legion Building, San Bernardino, California, Tuesday, October 9-12, 1928

Tuesday, October 9, 1928

Meeting called to order at 9:40 a.m. by A. K. Warren, chairman of the organizing committee.

Moved by C. C. Kennedy, and seconded, that the matter of permanent organization be deferred until 9:00 o'clock Wednesday morning. After discussion motion was withdrawn and it was decided to proceed with business, except as to constitution and by-laws.

Mr. Warren, by way of introduction, stated that the Association was brought about by men working throughout the country; the local Association was started by Mr. Gillespie, who called a meeting in San Francisco on June 11, 1928, at which fifty-one representatives were in attendance, and an organizing committee composed of C. G. Gillespie of Berkeley, Philip Schuyler of San Francisco, Andrew Jensen of Fresno, O. E. Steward of Anaheim, and A. K. Warren of Los Angeles, was elected. The committee by letter-ballot elected Mr. Warren, chairman, and he was charged with the duty of carrying the meeting through to its conclusion.

The chairman then called for the roll by the secretary, who reported 97 members.

The chairman then announced the names of the committeemen appointed during organization.

He stated it was due to the efforts of Mr. Goudey, the chairman of the program committee, that we were able to get together.

The organizing committee also appointed W. T. Knowlton and C. C. Kennedy as representatives to the Federation, to act on the board of control.

Mr. Gillespie was called on for a report of the work of the organizing committee. He stated that there was not much to report except that we had gotten to the point of holding our first meeting.

Mr. Kennedy was called on for a report on the National Federation. He stated that he had received two or three letters from President Emerson of the National Federation, and had been present at the meeting in Cin-

cinnati last fall, when the committee of one hundred presented its report which was the basis of the organization. It was formed at the meeting of the American Society of Civil Engineers in New York City last January, and Mr. Emerson was elected president, and the various committees appointed. The most important function is the publication of contributions which make literature in the field of sewage treatment. The first Federation Journal arrived just in time for the San Bernardino meeting and although he had not seen it he thought the editorial committee headed by F. W. Mohlman, editor-in-chief, evidence of the worth of articles appearing in the Journal.

It is the intent that the Federation shall be merely an association for conference and for interchange of ideas and information. Our entering with such a good membership he considered a creditable thing for the Pacific Coast; the highest membership in other associations within the Federation, according to last reports, was 84, which indicated another record for California.

The chairman brought up the matter of dues and stated that one dollar of the two dollars collected went to the National Federation for the Journal, and since the Federation by-laws provided that dues shall be payable on January 1, for the ensuing year, we would have to pay dues again in a short time; however, he felt most of us could stand that for the advantage of getting into the Federation at its inception.

The chairman also stated that our local association hoped to publish proceedings of all meetings, with discussions, and additional papers which might be sent in between meetings.

The meeting was then opened for discussion and papers, other business being postponed until Wednesday morning, October 10.

The first paper was on 'Water Tight Sewer Joints', by Herman P. Cortelyou. Mr. Cortelyou was unable to attend, and the paper was read by the secretary. It was discussed by Messrs. Warren, Schuyler, Koebig, Sr., Rawn, Kennedy, Knowlton, Foster, and Gillespie.

The second paper was on 'Cleaning Sewers', by F. A. Batty, and was discussed by Messrs. Goudey, Loucks, Lockwood, Adams, Bowlus, Knowlton, and Foster.

(Note: Since the San Bernardino meeting a letter has been received from C. A. Emerson, Jr., chairman of the Federation, advising that dues paid during 1928 carry through 1929, so it will not be necessary to collect additional dues from present members.)

The third paper, 'Standardizing Sewer Pipe', by E. L. Phillips, was read by the secretary and discussed by Messrs. Collins, Rawn, and Koebig, Sr.

The meeting adjourned for luncheon, and reconvened at 2:00 p.m. at a joint meeting with the Department of Engineers, Councilmen, and Street Superintendents, W. T. Knowlton, chairman.

Mr. Knowlton gave a report of the Committee on Trade Wastes and Sewage Disposal, which was discussed by Messrs. Gillespie, Schuyler, Kennedy, and Goudey. O. A. Gierlich moved and it was duly seconded and carried that a committee of three be appointed to work with the legislative committee of the League of California Municipalities. The committee as later appointed was H. A. Postlethwaite, Chester A. Smith, and C. G. Gillespie.

Mr. Knowlton turned the chair over to Mr. Warren.

Professor Reynolds read a paper on 'The Financing of Sewer Maintenance', which was discussed by Messrs. Perry, Schuyler, Warburton, and Knowlton.

Mr. Warburton moved, and it was duly seconded and carried, that a committee of three be appointed to work with the legislative committee of the League on an enabling act to cover the subject of sewer maintenance. The committee appointed later was Messrs. Warburton, Batty, and W. J. Locke.

Mr. C. C. Kennedy read a paper entitled 'Know Your Sewage'.

The meeting adjourned and most of the members took an interesting trip to the new San Bernardino sewage treatment plant under construction.

Wednesday, October 10, 1928

The session was called to order by A. K. Warren, chairman.

Mr. Gillespie read a paper on 'Sludge Digestion', which was discussed by Messrs. Perry, Knowlton, Burgess, Reynolds, Kennedy, and Schuyler.

Mr. Kennedy moved, and it was duly seconded, that the governing board of this Association appoint a committee to work out a standard form of plant operating reports. After discussion the motion was carried.

The chairman introduced W. J. Locke, executive secretary of the League of California Municipalities who addressed the Association.

The chairman called for the report of the combined committee on constitution and by-laws, and nominations, Mr. C. C. Kennedy, chairman.

Mr. Kennedy read the constitution and by-laws.

Mr. Warren commended the committee and asked for discussion.

Mr. Goudey suggested that the provision requiring former members to pay all back dues be amended to allow paying current dues, by adding clause 'Except when dues may be remitted by the governing board', stating that they should not be made to feel they had been expelled or rejected.

After discussion Mr. Knowlton moved that the report of committee on constitution and by-laws be accepted as read, and a vote of thanks be given to the committee. Motion seconded.

Mr. Warburton suggested an associate membership for material men rather than putting all members in one class as a means of avoiding possible trouble in the future.

Mr. Warren stated that point had been given consideration and the committee felt that material men entering the association would do so to get better results.

Motion carried unanimously.

Nominating committee named the following officers:

L. B. Reynolds, Stanford University, president.

F. A. Batty, 942 South Bronson avenue, Los Angeles, first vice-president.

B. J. Pardee, City Hall, Visalia, second vice-president.

E. A. Reinke, 102 Civil Engineering building, Berkeley, secretary-treasurer.

Directors:

F. M. Lockwood, City Hall, San Diego, one-year term.

A. W. Wyman, superintendent sewage plant, Pasadena, two-year term.

Philip Schuyler, 114 Sansome street, San Francisco, three-year term.

A. K. Warren, 202 Law building, Los Angeles, four-year term.

C. G. Gillespie, 102 Civil Engineering building, Berkeley, five-year term.

Chester A. Smith moved report be accepted and nominations closed. Seconded and carried.

Mr. Kennedy assumed the chair and on motion by Chester A. Smith, duly seconded, a unanimous ballot

was ordered cast for the nominees of the nominating committee as officers of the California Sewage Works Association.

Mr. Warren returned as chairman.

Mr. Gillespie suggested that George W. Fuller of New York be made an honorary member, referring to him as the 'ranking dean' of sanitary engineering in this country, telling of his early work in the profession, his interest in Association affairs and the great lift he gave our Association when we organized in June. At the suggestion of the chairman this was put in the form of a motion and duly seconded.

Alva Smith called attention to the fact that the constitution allows only one class of membership and stated that a motion to amend the constitution might be in order.

It was also brought out that Mr. Fuller has paid his dues and is a member in good standing of this Association.

Mr. Gillespie suggested that Mr. Fuller be recognized as our first member, since his name heads the list in the organization meeting in San Francisco, and that we express our appreciation for what he has done.

Mr. Warren suggested that Mr. Gillespie make a motion to that effect, which was done, with instructions to the secretary-treasurer to transmit a copy of the motion to Mr. Fuller. Motion was seconded and unanimously carried.

The chairman stated that one more matter remained, and that was to accept and approve the constitution and by-laws of the Federation, as contained in the Sewage Works Journal.

Moved by Mr. Koebig, Jr., seconded and unanimously carried, that the constitution and by-laws of the Federation be accepted by the California Sewage Works Association.

Moved by Mr. Knowlton, seconded and unanimously carried, that resolutions referring to State-aid research, and sewer rental bill be adopted.

Moved by Mr. Goudey, seconded and unanimously carried, that the secretary-treasurer be instructed to write a letter to Secretary Mack of the San Bernardino Chamber of Commerce, thanking him for his assistance in arranging meetings, printing, etc.

The business meeting was concluded and turned over to papers and discussions.

Mr. Goudey presented a paper on 'Odor Control by Chlorination', which was discussed by Messrs. Schuyler, Kennedy, Rawn, Reinke, Warren, and Chester Smith.

The session adjourned until 2:00 p.m., most of the members attending a luncheon discussion in a body.

Mr. Wyman read a paper on 'Trials and Tribulations of a Sewage Works Operator', which was discussed by Messrs. Warren and Goudey.

A laboratory demonstration of tests for settleable solids, pH, relative stability, and free chlorine, was given by Mr. Reinke, and those present were given instruction in making each test.

Group of 'Sewage Purifiers' on Top of Lake Arrowhead Dam, October 11, 1928. Left to Right: C. G. Gillespie, Thos. Warburton, F. E. De Martini, Donald Davies, Jr., Leon B. Reynolds, R. F. Goudey, J. F. Byxbee, E. E. Hansen, E. A. Reinke, Mrs. Horace Hall, Miss 'California', M. A. Heinzman, Mrs. C. C. Kennedy, C. C. Kennedy, D. E. Perry, M. Ellinger, G. T. Luippold, Philip Schuyler. Carl Wilson was the Photographer.

The meeting adjourned till 9:15 a.m. Thursday, October 11, when many members and their families took a trip to Lake Arrowhead, visiting the north sewage plant in the morning and the south plant in the afternoon. Field demonstrations, sludge and scum sampling and testing, were given. A delightful lunch was furnished by the Lake Arrowhead Co., and the party enjoyed the rain and snow storm. The members expressed their appreciation for the courtesy shown by the Lake Arrowhead Co. and their fine hospitality.

A number of members also assembled on Friday morning, October 12, and in spite of inclement weather, a trip was taken to the Pomona sewage treatment plant, and through the pipe manufacturing plant of the Pacific Clay Products Co. at Santa Fe Springs, where the company furnished luncheon. The courtesy

and hospitality of the Pacific Clay Products Co. and of the men in the organization who served as guides around the plant, were appreciated by all the members present.

In the afternoon some of the party visited the Pasadena activated sludge plant and others the Harbor City plant of the Los Angeles County Sanitation District, the weather having delayed the trip, so that both could not be seen. Those members attending the trips felt amply repaid for the time spent.

Respectfully submitted,

E. A. Reinke, *Secretary-Treasurer.*

NOTES ON SEWAGE TREATMENT IN EUROPE

In Stuttgart, Germany, "a property owner is paid a substantial sum to discontinue using his cesspool". The digestion of screenings is being developed by Imhoff.

"It is apparent that the adoption of the activated sludge process, irrespective of the degree of treatment, permits the maximum salvage from old and existing plants. * * * With a better understanding of sludge digestion and with the inclusion of pre-settling, (it) * * * has become increasingly attractive and offers possibilities under a variety of conditions. * * * the combination of surface aeration and diffusion is in operation at Birmingham and the Essen-Rellinghausen works. * * * For the large works, it appears that demonstration units should be operated in parallel before a decision (as to the system to adopt), is made. * * * very little oxygen has been taken out of the diffused air in its vertical passage through an aeration tank. The Imhoff system of retarding with paddle wheels increases perceptibly this ratio which is an outstanding advantage of the combined surface and diffusion system."

For optimum digestion, German practice is to mix fresh solids and digested sludge by natural means during settling, instead of delivering the fresh solids to an independent tank. Secondary digestion with heat often proves advantageous.—Geo. B. Gascoigne (Eng. News-Rec., July 19, 1928).

Relation of California Sewage Works Association to League of California Municipalities

By Wm. J. Locke*

Mr. Chairman and Gentlemen: This request to appear before you this morning was rather a surprise, as I did not know anything about it until a few moments ago, and it leaves me at some disadvantage, because I do not know just what you would like me to say, or, I might add, what I should say.

Some few months ago, when this organization had its initial meeting in San Francisco, I asked a few of the promoters, those who were perhaps instrumental as leaders in bringing about its formation, why it was desirable to have an organization separate and distinct from the branch which we now have in the League of Municipal Engineers, and I was informed that organizations of this kind exist in other states, and have been found most desirable and valuable. I was reminded, and conceded, that a great deal of money, public money, is expended for the construction of complicated apparatus for the disposal of sewage; that quite a number of various and different kinds of apparatus have been devised, and this apparatus is more or less successful, some much more successful than others. And, realizing that it involves public health and its maintenance, I appreciated at once the value of an organization of this kind. It certainly is foolish, it would appear, to expend millions of dollars, as we do in various portions of the State, for the purpose of devising apparatus to take care of sewage, and keep no record of the operation of these expenditures, or the apparatus which is devised by the money raised for that purpose.

I was reminded, also, that here in California we are confronted with problems which are peculiar to this State, by reason of its semi-arid situation, and the limitations of our rainfall season. In the eastern part of the country, and in most of the civilized countries of the world, rain, as we know, falls during all seasons of the year, more or less, whereas, out here in the State

*Executive Secretary, League of California Municipalities.

of California, we have our winter season, and then our summer season, which is practically devoid, almost entirely, of rainfall. As a consequence, we have a great many dry rivers in California. We have been treated to a lot of humor, more or less, concerning our rivers. People from the east come out here, and we are obliged to point out to them, 'That is the 'So and So' river', and they look with considerable surprise when they find little or no water in the river. But these facts, of course, contribute to making the problem of sewage disposal out here in California a different problem than we are confronted with in other portions of the country, and, as a consequence, we are devoid of the experience of other countries, or other places in this country, where the conditions are so different.

In a talk with Mr. Gillespie, not a very extended one, though, he remarked that this peculiar situation, which obtains in our State, while in some ways a disadvantage, in others has its advantages. I can fully appreciate the importance of an organization of this kind, and it is with considerable gratification that I learn that you have such a large attendance.

A question which arises at once, it seems to me, and one perhaps in which you are very much interested, is to determine just what relationship, if any, it would be advisable for you to have with what might be termed the 'parent' organization of city officials of the State, the League of California Municipalities. Today we are celebrating, in a way, the thirtieth year of the existence of this organization, an organization of city officials of the State of California. We have in round numbers, perhaps, nearly 270 incorporated cities and towns in the State, of all sizes, some of them quite small, and others of course running into millions in population.

In the early history of the League, all city officials assembled together, regardless of the character of office which they held, whether elected or appointed, legislative or administrative, and discussed these various problems. After seven or eight years meeting in that way, it was suggested that it would be more desirable, more economical, and more efficient, if the officials divided at least a portion of their meetings into departments; and as a result, it has been the practice, for the past twenty-one years, to hold a portion

of our sessions, about half of them, in these divided departmental meetings, and we have, altogether, now about six different departments.

It is the practice now to meet all together, with the exception of the health officers, in our morning sessions, and in these morning sessions, a program is arranged of subjects which are of interest to all city officials generally, regardless of the office they may hold. You can realize, of course, that there are questions and problems and subjects which are of general interest to all city officials, and that is the reason why it has become an established practice of our organization to arrange our morning sessions in that way.

In the afternoon, we divide into departments: the city planners meet separately; the engineers, councilmen and street superintendents meet in another separate department; the city attorneys again in another; the city managers in another, and so on. I think it is a wise arrangement.

I think our plan for arranging the program is a good one. It has been our practice for the executive secretary to send out, prior to each annual meeting, a ballot. That ballot differs from the ordinary ballot which you use at elections, by having thereon, instead of the names of officials, the names of subjects—the title of different subjects—and the city officials all over the State are requested to mark on the ballot their first, second, and third choice of subject. Now, we give a weight to three votes in this way: their first choice is given a credit of one; their second choice, two-thirds, and their third choice, one-third. The vote is counted, and in that way we ascertain the subjects which are of most interest, at least at the time being. From this ballot, and from meetings which are thereafter held in different parts of the State by those who are interested—take the greatest interest in the organization—our program is prepared, and so far it has worked very satisfactorily, and I think you must concede it is perhaps the most democratic way in which a program could be devised.

Now, just what relationship it would be advisable for this organization, if any relationship is thought desirable to bear to the League of Municipalities, is perhaps a question for consideration. We must realize, of course, that numbers give strength. We can

always resort to the old fable by Æsop, where the bundle of sticks was taken as an illustration of the strength of united organism. I think it would be desirable if this organization were to bear some relationship to the League of California Municipalities. The only question that I have in mind in that connection is as to the advisability of having too many divisions or departments. There has always been a question in my mind, just how far we should carry that idea. I do not know that it would be an advantage—perhaps it would be a disadvantage—for you to be affiliated with the Department of Engineers of the League of Municipalities. You have a separate and distinct function, and, if you have problems enough at each of your annual conventions, to take up your entire time, it would probably not be wise to be connected with the Department of Municipal Engineers, because they would undoubtedly have on their program questions which would not be of direct interest or concern to you.

You are interested in the disposal of sewage and the operation of sewage treatment plants. You are not interested in the construction of sidewalks or pavements, and, therefore, a tie-up with the Department of Engineers, Councilmen and Street Superintendents of the League of California Municipalities, would necessitate your sitting in on the discussion of questions which are not, perhaps, of direct concern or interest to you, and it would thereby involve a considerable loss of time. Now, the object of all these meetings is, of course, to get the greatest possible value from them. There is no question of greater importance than the maintenance of public health, and the proper disposal of sewage is absolutely essential to the maintenance of public health, as we all must concede.

It presents, perhaps, so many problems, that a separate organization, such as you have formed, is most desirable. I would like, however, to see this organization affiliated in some way—perhaps it might be advisable to arrange for your future meetings at a time when the League of California Municipalities is meeting. On the other hand, we find this difficulty, this objection, that it results in such a large convention that only the large cities, having plenty of hotel facilities, can accommodate the attendance. That is an-

other matter to take into consideration, and yet, your problems are the problems of other city officials. The city councilmen should know something of this important question that you discuss. You can readily see, therefore, that there are some matters to be said, and some argument to be advanced, on both sides of this particular phase of the question.

I was requested to come here this morning because of the absence of our president, J. C. Albers, who went to Los Angeles, I believe, to greet some of the gentlemen on the program, who are going to talk on 'Aviation' and coming out here by plane; and I think I heard the noise of planes, and perhaps they have arrived for the main event in the auditorium.

I want to take this opportunity to thank you for the courtesy and honor that has been extended to me, as a member of the League of California Municipalities, to assure you of our cooperation, appreciation of the importance and value of the work in which you are interested, and to tell you we are only too anxious and willing to help at all times, to give you every possible aid and assistance that we can. I appreciate, and I think that most of the city officials appreciate, the importance of these problems that concern you. If there is anything that the League of California Municipalities can do to further your interests, and help you with the solution of these problems, we shall be only too glad to do it.

I do believe that some kind of a tie-up should be worked out, so that you will keep in close touch with the parent organization, if I may refer to it as that, the League of California Municipalities. We have occasion to go before the Legislature, as you know, every two years, and there is always some new legislation to be presented, and that in itself would make it a desirable thing to have some close relationship, because, the greater we are in numbers, the greater we are in influence before the state body, and sometimes it becomes necessary, in order to secure appropriations, to be able to wield as much influence as we can.

I thank you, Mr. Chairman.

Water-tight Sewer Joints

By Herman P. Cortelyou*

Although in storm drain construction, where pipe drains are laid through soil which carries ground water, it is unnecessary to stop leaks and, in fact, it is often advisable to omit the mortar from portions of the joints under such conditions in order to admit the ground water into the drain and thus lower the water table in the district; nevertheless, with the use of separate sanitary sewers instead of combined sanitary and storm drainage, as is often customary in other locations, it is necessary to exclude all possible ground water from the sewer system. If this is not done, the required capacity and cost of collecting and outfall sewers, and also of pumping plants and sewage treatment plants, is unnecessarily increased. This burdens the public with an unnecessary and perpetual charge for the increase in interest and sinking fund on bond issues, and operating charges if pumping is required.

Amount of permissible leakage—For many years the city of Los Angeles had no specific requirement for the permissible amount of leakage into sewers, although efforts were continually made during construction to keep it at a minimum. However, with the passage of the bond issue for the new outfall sewer, and the extension thereby of lateral sewers into a very extensive territory in the western part of the city, where ground water was universally encountered, it became apparent that more definite requirements should be set up in this connection. It was decided that in all cases of leakage the amount should be definitely measured and that this leakage should be limited to two gallons a minute per inch of diameter of sewer per thousand feet of sewer which is laid in wet ground. This limit has been reduced by successive stages during the past two years to six-tenths of a gallon per minute. In addition, it is stipulated that, regardless of the total amount of leakage, if any individual leak can be located by the use of mirrors reflecting a beam of sunlight into the sewer from a manhole, the contractor

*Engineer of Construction, City Engineers' Office, Los Angeles. Paper read by E. A. Reinke, Secretary C. S. W. A.

must take the necessary steps to stop such an individual leak. This can usually be located, especially if it comes into the sewer from the side or top, by counting the number of joints from the manhole to the leak and then opening an excavation to the sewer at that point.

Measuring Leakage—To measure the leakage we used a triangular or Cippoletti weir of sheet metal. This was proved to be perfectly satisfactory, although great trouble was encountered at first in holding the weir in position in the channel of the manhole, as the pressure from the water which is backed up behind the weir is considerable and tends to overturn it. This difficulty has been largely overcome by the use of a metal band set at right angles to the face of the weir on the downstream side and fastened to its lower perimeter, but with the upper ends loose so that a bolt can be used to expand the band tightly against the sides of the channel. Leakage underneath or along the sides of the weir can be stopped by the use of a little clay.

Methods of Leakage Control—Several methods of controlling leakage into sewers through the joints have been used successfully in our work.

Regardless of the method of making the joint, first attention must be given to controlling the water in the bottom of the sewer trench during and after pipe-laying, as it is practically impossible to secure a tight joint of most types that are used, if any water comes into or around the joint, either during or after pipe laying. Water in the trench can be controlled in medium sized sewers by the use of a mattress of coarse rock underneath the pipe through which the water flows to the sump holes at which the pumps are located. In lieu of this, it has been controlled successfully by widening the trench sufficiently to provide a small ditch below subgrade and at one side of the pipe-line. In several cases in the harbor district, where material near subgrade was in the nature of a very fine sand, the water table has been lowered in the trench by means of a series of sand-points, or pipes having a few feet near the end perforated and covered with fine screen. These are driven outside the trench on each side with sand points at intervals of about

20 ft. or less, which are connected with a common collector line to the electrically driven pumps.

Another feature which is often overlooked, but which it is impossible to stress too highly, is that after the joint has been made the workmen in the trench must be kept from walking on the pipe. This is something which has frequently been the cause of excessive leakage, even where all other precautions were properly taken.

Several methods of making the joint itself have been used successfully in the past few years, among which may be mentioned the protection of the joint by a

Tongue and Groove Cement-Concrete Pipe, 30-in. Diam., Showing Special Bands Used for Grouted Joints, Santa Cruz Sewerage System. C. G. Hyde, Designing Engineer

collar of plastic clay, the use of bituminous filler, or the use of a grout poured into the joint and retained by special forms.

With the plastic clay collar, it is customary to plaster the joint with 1 : 1 mortar, and then to entirely surround the same with a layer of clay which has been worked up to the consistency of putty. This collar is about an inch or more thick, and care should be taken to have it extend entirely around the joint, under the bottom as well as on the sides and top.

The bituminous type of filler is usually a successful

method for making tight joints, but, as a rule, it is rather slow and on this account it is not very popular. Some time can be saved by assembling the pipes in pairs and pouring these joints on top of the bank, thus pouring only every other joint in the trench.

About two years ago we experimented with a patented bituminous joint put out by the Presstite Engineering Co. of St. Louis, which consisted of a premolded bituminous gasket confined in cheesecloth casing. This joint material consisted of a gasket molded to fit the space between the spigot and bell of each particular size of pipe, and the gasket was placed in the bell of the pipe just laid, after which the spigot of the next pipe was placed in position and a special type of press was used to force the spigot tightly into the bell. In theory, this seemed to have many advantages, although in practice considerable difficulty was encountered in using these gaskets. The principal trouble came from the fact that there was a difference between the dimensions of eastern and western pipe in the matter of the spacing between the bell and the spigot, and the manufacturer seemed unable, or indisposed, to turn out a product which would fit the dimensions of local pipes.

The next experiment in sewer joints which was tried was the use of a poured joint of 1:1 cement grout, confined by the use of patented thin metal forms known as the 'Weston Gasket and Form'. These thin metal forms are wired to the pipe and are in such a position that when grout is poured into the joint it is confined exclusively to the spacing between the bell and spigot. This joint has given very satisfactory results.

In conclusion, I will say that our experience indicates that it is possible to control leakage into sewers and to limit it to a very small amount, but this can only be accomplished by extreme care, regardless of the particular type of joint material or form that is used.

DISCUSSION

Mr. Warren stated that the problem was very important to sewage works operators, keeping in mind that the general cost of treatment plant is about $100,000 per million gallons daily capacity, and that the cost of some sewer lines is as high as $30,000 to $40,000 per million-gallon capacity per mile.

Mr. Schuyler discussed the question from his experience of over nine years as a contractor, saying that he was as guilty as the rest in careless construction and that he had often thought of writing a 'practical specification' with the idea of insuring tight joints. He added that a clever sewer-pipe layer could easily put it over on an inspector or engineer, and emphasized the importance of having the ditch dug to exact grade, tamping the subgrade properly, and seeing that each joint was properly made. He classed as 'criminal' the laying of sewers without cementing joints, as had been done to his knowledge in many places. Mr. Schuyler also favored a flexible joint, stating that with uneven settlement in the trench a rigid joint could not help breaking. In a great many cities to his knowledge during the rainy season with high ground water the sewers carry from 50 per cent to 100 per cent more than the normal sewage flow. He also urged the adoption of a leakage test in specifications, and added that it did not cost the contractor more to do a good job than a careless one.

Mr. Koebig, Sr., gave his experience in laying one of the first sewers in Southern California in 1888 in the city of San Bernardino. He stated that some of the worst water conditions were experienced on E and F streets between Second and Seventh. By enforcing specifications which were right, requiring ditch to be dug to exact grade, bell holes to be made by hand, a wide and open type bell hole for joints, gravel and concrete mattresses with side drains in wet ground, and careful selection of inspectors, an almost watertight job was obtained. At one time he had to reject eight carloads of defective pipe. He selected inspectors and engineers from the Santa Fe Railway system instead of political inspectors.

Mr. Rawn brought out the point that it was usually not possible to dig a trench in wet ground with a ditch digger, and the custom was to dig below grade and backfill with gravel, tamped to precise grade. He agreed with Mr. Schuyler that joints should not be too rigid, he having seen many failures in sewers which he could not attribute to other causes. He also stressed the necessity for taking steps to prevent breakage, particularly controlling the width of trench and using

care in backfilling. He thought good specifications and inspection should solve the problem.

Mr. Kennedy agreed with the previous speakers and gave it as his experience that the only practical method

Laying Vitrified Pipe Sewer with Asphalt Joints in Wet Ground for Sewer System at Lemoore, California; C. C. Kennedy, Designing Engineer

of getting results was to pass the burden to the contractor by requiring a test on the finished pipe. He expressed the opinion, based on his experience, that satisfactory results could be obtained in trenches up to 22 ft. in depth, by filling with sand in 6-ft. layers,

wetting each layer and allowing it to dry before the next was added.

Mr. Knowlton stated that Los Angeles city proposes specifications along the line of Mr. Cortelyou's paper.

Mr. Foster, in reply to a question by Mr. Jencks, stated that Los Angeles county has two tests for leakage, a pressure test in dry ground and an infiltration test in wet ground, which they find necessary in dealing with inexperienced contractors, who, without such a test, would have a beautiful collar of cement around the upper half of the pipe and nothing below. In wet trench the county uses the Weston joint mentioned in Mr. Cortelyou's paper. They propose to change their specifications to require that when the contractor excavates wider than the minimum width trench he shall strengthen the pipe. He described the first experience of a contractor at Belvedere, where after filling the pipe with water the contractor stepped on the back fill and sunk nearly out of sight in the mud caused by leakage through the pipe. The line was later satisfactorily repaired.

Mr. Gillespie remarked that the subject could be discussed all day and suggested that written discussions of this and other papers be invited, stating that he might like to write a discussion of the economic side of the question, showing how much the city council might be justified in spending for these features.

The chairman agreed and asked that written discussions be sent in.

Operation of Sewage Treatment Plants in Ohio—The efficiency secured, and the introduction and operation of the Sewer Rental Law, are subjects of an article by F. W. Waring in Public Works for July, 1928.

"Most of the communities are beginning to realize the necessity for skilled operation and supervision of the plant, which can only be obtained by properly educated men."

A Research Laboratory for the State of Texas has been established at the State Agricultural and Mechanical College. Investigations are to be made of stream pollution, the Dunbar filter, the fertilizing value of sludge, and separate sludge digestion.—(Pub. Wks. Aug. 1928.)

Cleaning Sewers

By F. A. BATTY*

The cleaning and maintenance of sanitary and storm sewers must all be done while the sewers are functioning, there being no opportunity to shut off or by-pass the flow, excepting where there is a separate system when there is ample time during the dry season to do most of the cleaning and maintenance of storm sewers.

Sewers are usually designed with a self-cleansing velocity, and this in itself would lead one to believe that cleaning would be unnecessary.. This is the case with a large number of sewers, but there are innumerable conditions arising which require the constant cleaning, and attention to properly designed sewers.

One of the greatest causes for heavy maintenance is improper workmanship in the construction of sewers. Many of the older sewers were built under lax or no inspection, where the contractors were indifferent to the necessity of good workmanship, and the adherence to line and grade was approximate only. There is a tremendous difference in the cost of maintaining properly laid sewers, or the reverse.

The following data refers to methods, etc., used in the city of Los Angeles. One, or one and a half-ton trucks are used for maintenance, equipped with delivery type body; canopy top and side curtains being necessary for wet weather. The crews consist of from three to six men, one of whom is a foreman and is usually the driver. The equipment on trucks is approximately as follows:

350 ft. of iron sewer rods,

100 ft. of wood sewer rods,

both of which have various attachable hooks, spears, scoops, root cutters, etc.

500 ft. of 2½-in. fire hose.

Picks, shovels, bars, gads, buckets, lanterns, flash lights, mirrors, spotlight with 50 ft. of cord, rope, hydrant wrenches, rod wrenches, hammers, sledges, small tools, and rubber hip boots for all of the crew. The men supply their own jumpers, and rubber coats.

The iron rods are ⅝-in. black pipe, fitted with spe-

*Maintenance Engineer, Engineering Department, City of Los Angeles.

cial screw coupling, with hexagon collars at one end for use of wrench, and are 3 ft. in length. These rods are made in the city shop. The wooden rods are the regular commercial type manufactured by many firms, also 3 ft. in length.

Both the iron and wooden rods are equipped with attachable hooks, scoops, spears, etc., all of which are 'home made' according to various designs developed from practical use.

The department also uses hickory rods 2 in. by ¼ in. by 10 ft. in length. These rods are flexible, and can be used by inserting them into the sewers from the surface when the manholes are full of water. This is sometimes very effective. These rods are light and buoyant, and can be used to pass a line through a sewer. They are coupled together by being tied with heavy twine or wire.

The fire hose is regular 2½-in. standard fire hose, and has generally been condemned by the fire department. All trucks are equipped with a Victory self-propelling nozzle for use on fire hose. This nozzle is self-propelling, and is the most useful tool the department has acquired, enabling two or three men to insert as much as 300 ft. of hose into a sewer.

Flushing is the greatest cleaner for sewers. Sewers should be periodically inspected at least once in six months, and as often as once a month where a sewer is known to be bad.

The manholes should be washed down, the sand or debris removed from the channel, and if not running freely and sediment, grease, or roots are found in the sewer, rods should be inserted, and the sediment loosened, and the sewer flushed. The flow should be slowed up by damming at the lower manhole, and the heavy materials collected and removed to surface by buckets.

Sewer stoppages are an every-day occurrence, and must be relieved at once, or the resulting damage may be enormous especially in the business districts where valuable goods are stored in basements. A stoppage in the business section is usually discovered by the sewer backing up into the lowest basement through the house connection. The department is generally notified by phone of a stoppage, and one or more crews are dispatched to the scene of the trouble, adjacent

manholes are opened, and the crew immediately proceeds to insert the rods up the sewer from the next manhole below the stoppage. If the stoppage is near the manhole, wooden rods can be used, being quicker than iron rods. If at a greater distance, iron rods are necessary, as they are stiffer and have no play in couplings, and can be hammered or jacked against a stoppage. Upon the removal of the obstruction, the sewage rushes down along the sewer, sometimes flooding the lower manhole and causing the men to climb out without removing the rods. Occasionally a string of rods is washed down the sewer and has to be located and removed. If the stoppage is caused by an accumulation of sand, it may be necessary to remove same by scrapers and by flushing with hose. This condition may extend for some distance along the sewer line, making it possible to flush and remove sand simultaneously from several manholes. Occasionally, after every effort has been resorted to, a stoppage can not be removed. Then it becomes necessary to dig up the sewer. The location of the stoppage is measured by counting the number of rods inserted into the sewer from the lower manhole to reach the stoppage, and the same measurement made on the surface. There should be no variation in the length of the rods used (that is 3 ft.). Breaks or crushed sewer pipes are located in the same manner. Pumping (discussed later) is sometimes necessary under these conditions.

Broken pipes in sewers is a condition that means a lot of work and worry to the department. This condition usually causes a complete stoppage, the sewage either flowing out of the lowest plumbing fixtures into the buildings along the line if below street grade, or else out of the lowest tops of the manholes above the break. In either case, the residents are anything but pleased. Pumps must immediately be procured and the entire flow of sewage pumped from the manhole above the break to the manhole below, usually through a pipe or flume. This condition generally occurs where sewers are at greater depths and reconstruction difficult, so the pumping period may be of long duration.

Barnes duplex trench pumps, equipped with gasoline motor with manifold discharge to operate two or four fire hoses, mounted on auto chassis with solid

rubber tires, are the most satisfactory pumps the department had found for pumping the smaller sewers.

Open runner centrifugal pumps are necessary when sewers of larger capacity are to be pumped. These pumps should be run by gas engines, and should be mounted as a completed unit on wheels or skids. All gasoline driven pumps should be equipped with effective mufflers, as they have to be run continuously and the nearby residents will complain if not so equipped. If the pumping period is to be of long duration, it is more satisfactory to install electric motors for running pumps.

The importance of having pumps, that are used for the emergency pumping of sewage, in first-class condition at all times and ready for use, can not be too strongly stressed. The tendency for other departments, contractors, etc., to endeavor to use pumps that are standing idle, is oftentimes difficult to discourage, but pumps should be kept for only one purpose, pumping sewage.

Sewer cleaning rods and tools that are dragged through the sewers are not necessary for general use, although when tree roots, accumulated grease, or solid materials settle in a sewer, these tools are very useful. The first thing to do with this type of tool is to get a line or cable through the sewer. This is sometimes difficult, and in the case of a stoppage, impossible. There is no question but the work of these tools is thorough when operated, but there is always the danger of getting the tool stuck in the sewer, or of otherwise damaging the sewer.

The cleaning of large sanitary sewers is not often necessary, although there are times when sand or gravel accumulates at some locations. This is generally removed by dragging a cable through the sewer, with agitating devices attached thereto, loosening up the deposited material so that the flow of sewage washes it on down.

The flow of sewage in large sanitary sewers is generally too heavy and the sewer gas is too strong for men to enter the sewer. If the flow in a large sewer is low and the gas not strong, accumulated material may be removed by running small wagons into the sewer, loading the same with buckets of material, and hoisting the buckets to the surface at adjacent man-

holes. This method of removing material was used under the writer's supervision in a portion of the Glendale outfall, a 54-in. sewer of semi-elliptical type. During the heavy rain in February, 1927, a manhole was washed out at the edge of the Los Angeles river, causing the sand and boulders to completely fill the sewer for a short distance, and wash sand, boulders, and debris into the sewers for several thousand feet. An opening was first made through the debris at the upper end, sufficient to allow the sewage to flow on down the sewer; the maximum flow of sewage being about 10 or 12 in. deep, and the sewage comparatively fresh. Then the removal of debris was started from the lower end by the wagon and bucket method, buckets being hoisted to the surface by gasoline hoists. The manholes on this sewer being about 1000 ft. apart, and the sewer being 35 to 40 ft. in depth, wet electric batteries with extension cords attached, were located at intervals inside the sewer to furnish light to the workmen.

Storm sewers, particularly at locations where a steep grade runs into a flat grade, at times completely fill up with sand, which is removed by the wagon and bucket method after the storm is over. This work is very tedious in the smaller storm sewers of from 24 to 40-in. diameter.

The department recently had a very interesting problem in removing about 10 in. of sand and gravel from two miles of 27 and 30-in. sewer. For about half of this distance phenol waste had mixed with the gravel, forming an asphalt pavement in some places so hard that a shovel could not be inserted into it. This sewer was located between street car tracks, cars maintaining about a two-minute service. Also, the sewer was overloaded during daytime, the sewage standing as much as 4 ft. deep in manholes, and at night the sewer gas was so strong that a man could not stay in the sewer any length of time.

Sheaves were designed to attach at the top and bottom of manholes, ⅜-in. cables passed through the sewer, and various drags operated between manholes. These drags were pulled back and forth through the sewer with a Fordson tractor. A large amount of the gravel was removed from the bottoms of the manholes, and the balance loosened and washed down the

sewer. Car service was maintained on both tracks at all times.

The extensive use of flush tanks is recommended, as 'the more flushing the less stoppage', is well proven. Topographical conditions should govern flush tank installation and operation. The writer feels that night operation of flush tanks would be of much greater benefit to sewers and also to the local water works furnishing the water. This method seems to be somewhat visionary, but I believe it can be accomplished by the difference of night and day pressures on water mains.

The department is maintaining 2000 miles of sanitary sewers; 400 miles of storm drains; and innumerable culverts. The average flow of sewage is 100 million gallons daily.

DISCUSSION

In reply to a question by R. F. Goudey, Mr. Batty recommended manhole spacings of 300 to 400 ft. on small sewers, and 1000 ft. or more on large sewers; and replying to a question by Mr. Loucks, he defined small sewers as those up to 12 in., stating that stoppages occurred most frequently in the small sizes.

Walter H. Adams stated that in the L. A. County work operation of flush tanks would cost about $30,000 a year, which he considered high. Mr. Batty stated that the city of Los Angeles had had various experiences: Flush tanks are valuable where grades are flat; not necessary where velocities are 2 to 3 feet per second; and it is not necessary to operate them at all times; attention should be given, however, to systematical operation. In reply to a question as to whether he would recommend automatic flushing he believed automatic flushers good if water was properly handled, but his experience was that they usually flow too much or not at all. He has considered night flushing, using the high pressure in water mains at night to operate automatic flushers during the time when sewage flow is low.

F. M. Lockwood stated that in San Diego they had practically cut out all flush tanks, depending on flushing with fire hose at 'dead ends' of sewers, which they found a satisfactory method and which resulted in materially conserving water. Mr. Batty remarked that in San Diego grades were generally steep, whereas in

Los Angeles with some sewers flat, and as much as forty miles from the ocean, it was necessary to hurry things along and make better conditions at the lower end.

Fred. D. Bowlus described the use in Los Angeles County of a ball slightly smaller than the sewer diameter being put in at the upper end of the sewer, and depending on the head of backed up water to push it through. Mr. Batty remarked that such procedure would be rather disastrous if a tap stuck into the sewer, and Mr. Warren stated that Mr. Bowlus referred to new sewers.

In reply to a question as to the annual amount spent by the city of Los Angeles, Mr. Knowlton gave a figure of over $200,000, which he stated was not enough. He added that city officials in charge of finances do not see things below the surface of the ground. His office has collected considerable data on sewer maintenance throughout the country. He considered a committee on sewer maintenance should be named by the Association. Mr. Warren stated that Prof. Reynolds would discuss the matter in his paper at the afternoon joint session with the department of engineers, councilmen, and street superintendents of the League of California Municipalities.

Mr. Foster gave the experience of Los Angeles County, which has contracts with about 50 small water companies for furnishing water. They were charged a non-resident price of $1 to $2 per month, which was doubled with automatic flushers. He discussed the advisability of manual operation because of smaller original cost and only slight increase in cost of water.

SEWER MAINTENANCE IN BALTIMORE

Maintenance is made necessary on account of poor design, poor construction, depreciation, and misuse. "Fully 35% of the chokages in the sanitary sewers of Baltimore are due to the roots of poplar and willow trees." Where this occurs a ring of jute is first inserted in the pipe bell, then red puddle clay with coarse salt to about ½ in. of the end of the bell, and on this a finishing ring of mortar. This has proved effective in every instance. Planting on highways is now prohibited.—(Pub. Wks. Aug. 1928.)

Standardizing Sewer Pipe

By E. L. Phillips*

The natural aim of all designers and manufacturers is to have the finished product excel in strength, economy, uniformity, dimensions, appearance, etc. During the experimental stages in the manufacture of any product, a great variation in results is obtained and certain types are finally decided upon for certain uses.

In the manufacture of sewer pipe the manufacturer, by his choice of materials, his equipment and machinery, has been a very important factor in the development of high class pipe. Sewer pipe is no longer merely ordered, delivered, and installed, but must, in practically all communities, meet rigid tests in accordance with specifications which have been prepared by the authorities of the communities. These tests are the result of a long series of experiments with various mixtures and methods of manufacture, together with actual observations of pipe in use, and generally take into consideration the use for which the pipe was ordered. In general, the experimental stage is past, and the present problem is the combining of the results of past experiments, tests, observations of pipe in use, and all other data which affect the strength and lasting qualities of the pipe, in making up a specification which can be adopted without fear of disastrous results.

It has been noted that the differences in specifications of practically all cities are practically negligible, but each requires a special die for manufacture. It will also be noted that practically all changes in dimensions affect the manufacture of patented joints, and it has been the experience in several cases that premoulded joints did not fit, due to the fact that they were prepared for one set of dimensions and were used on another.

In the case of the city of Los Angeles, we have been particularly concerned with a standard size pipe, on account of our use of certain forms and gaskets used in making joints. Under old specifications the strength was found to be entirely satisfactory, but we provided

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for both a so-called 'Standard' and 'Deep and Wide Socket' pipe. The differences between these two types of pipe were entirely in the dimensions of the annular space, and upon investigation of the dimensions recommended by the American Society for Testing Materials, it was found that practically all of these dimensions came within the permissible variations for each of the above-named types of pipe, and in preparing our new specifications these dimensions were adopted.

DISCUSSION

W. H. Collins speaking for the Clay Products Pipe manufacturers stated that they are working on a standardized pipe which will meet the specifications of all cities and the American Society for Testing Materials. All pipe would be double strength, 'deep and wide' socket, so that pipe in one lot could be fitted into pipe from other lots and other manufacturers. They are also scoring pipe inside and out, to secure better bonds at the joints.

A. M. Rawn inquired if the salt glaze were omitted if as good a job could be made without it. He stated that western shales were softer than eastern, giving less margin between vitrification and burning, with a consequent higher mortality of pipe. Mr. Collins replied that tests were being made; and in response to a question by Mr. Warren, said he did not know the reason for originally adopting the salt glaze.

Mr. Koebig, Sr., in general discussion, stated that in over 50 years' experience, both in this country and in Europe, he had found the salt glaze the only assurance of vitrification. Without it pipe might be just as good but it would not be possible to quickly detect dipped or baked pipe from well vitrified pipe. Mr. Collins added that Southern California cities, in addition to specifying certain tests for sewer pipe, put them into practice, and it is quite impossible to slight specifications even though the contractor might desire to do so.

At Plainfield, N. J., complete odor control is obtained during the warmer months by the application of chlorine between 4:30 and 8:30 p.m.—(Wm. J. O'Connell, Jr.)

Report of Committee on Trade Wastes and Sewage Disposal

(Abstract)

By W. T. KNOWLTON*

During the twelve months since the 1927 convention, committees in the north, the south, and the central part of the State have worked on the question of sewage research, and it was decided after several meetings to hold a conference with Governor Young. The conference was held in Sacramento on June 12, 1928, at which time 7 or 8 committeemen met the Governor and Alex. R. Heron, director of the Department of Finance. They asked for $72,000 to be appropriated by the State to carry on sewage and trade waste research through the State Department of Public Health, and asked that the funds be provided in the State budget without the necessity of the League of California Municipalities sponsoring a special appropriation bill at the coming Legislature. Unfortunately the Governor and Mr. Heron could not see their way clear to appropriate money in the budget, and action must be taken on the floor of the convention. After a careful study of the budget it appears that $65,000 is the amount necessary for the research fund.

DISCUSSION

Mr. Gillespie stated that sewage disposal is a very new science, going back hardly more than 25 years, and the foundation on which our present day practice is based is very limited. There is hardly a case of sewage disposal in this State that would not have been benefited, and more positive results been obtained, if it had been made with a foundation of better scientific knowledge. The whole country needs more scientific knowledge of sewage disposal, which represents one of the most complicated sciences, depending on considerations more complicated than the digestion of food in the human system. New Jersey is taking the lead in research, and we have reached a point in California where we have gone about as far as we can in stimulating and promoting sewage disposal in the

*Metropolitan Sewer Division Engineer, Engineering Department, city of Los Angeles. Read before Joint Meeting of C.S.W.A. and Department of Engineers, Councilmen and Street Superintendents of the League of California Municipalities.

light of present knowledge. The appropriation is needed to put the whole practice of sewage disposal on a sound basis where communities will know what results they will be able to obtain. Mr. Gillespie described the manner in which New Jersey started its experimental work. Fly breeding in a sprinkling filter caused a nuisance for which the Department of Agriculture sent an entomologist to see if it could be controlled. The problems involved were so interesting that the Department of Agriculture in cooperation with the State Board of Health, went into them more deeply, and are now doing pioneer work in the field. They have found out things that mean a monetary saving to communities having problems in sludge digestion.

Mr. Schuyler entered a plea to 'keep California clean for our children and our children's children'. He stated the movement would bring no benefit to any particular group of men, but everyone should be interested in it. With continued growth of this State and increased population, problems of sewage disposal increase. We must prepare for the growth now. The California Sewage Works Association, recently formed, is for the purpose of utilizing tools which such research work would put in the hands of engineers and operators. City councilmen and those interested in civic affairs should see to it that the men who have charge of their sewerage systems are sent to the meetings of the Association. They will exchange ideas on maintenance of sewerage systems and sewage treatment plants, and will be trained in the efficient use of their sewage system. He believed the various communities will be benefited to the extent of thousands of dollars by sending delegates to the meeting.

Mr. Knowlton remarked that publicity on research had been sent out to many governing bodies and that the committees in the north, central, and south portions of the State will be glad to send out additional information. Mr. Goudey mentioned the necessity for handling the wastes of big industries, referring in particular to the fact that we have few woolen mills and tanneries in this State, most of the raw material being sent East and the finished products shipped West for consumption. This he characterized as an economic waste.

Mr. Kennedy reviewed the work the northern com-

mittee had done in conferences and communications with the Governor and the executive officer of the State Department of Public Health, and suggested that definite action should come from the floor of the convention.

Mr. Gierlich of Monrovia moved, and Mr. Perry of San Anselmo seconded, that a committee of three be appointed by the chair to work with the legislative committee of the League in preparing necessary legislation on research. Motion was carried.

The chairman appointed the following committee: H. A. Postlethwaite, Chester A. Smith, and Chester G. Gillespie.

RESOLUTION URGING STATE-AID FOR SEWAGE AND TRADE WASTE RESEARCH

Whereas the public health and welfare require reliable, efficient, and economical methods of treatment and disposal of sewage and trade wastes, and

Whereas scientific investigation of new methods of treatment and disposal of such sewage and wastes peculiar to California is urgently needed, and

Whereas, it is the sense of this Convention that such investigation should be provided and carried on by the State of California, and

Whereas the sum of not less than $65,000 is needed to conduct such investigations for the next biennium.

Now therefore be it Resolved by the California Sewage Works Association in Convention assembled that it does hereby urge the appropriation by the State of the sum of not less than $65,000 for the establishment and maintenance during the next biennium of the proper and necessary facilities for the accomplishment of the purposes above set forth

Resolved further that the California Sewage Works Association work in cooperation with the Legislative Committee of the League of California Municipalities to prepare for submission to the next session of the Legislature proper bills providing for the accomplishment of the purposes herein set forth, and this Convention does hereby respectfully urge the adoption of such measures by the Legislature of the State of California.

An Argument for Adequately Financing Sewage Research and Sewage Maintenance

Sprinkling Filter Overloaded and Neglected

Sprinkling Filter Operating Properly

Financing Sewer Maintenance*

By Leon B. Reynolds**

Some twenty years ago Lincoln Steffens wrote a book entitled 'The Shame of Our Cities,' setting forth the evils of our city governments. Since the publishing of this book much improvement has taken place in the administration of our municipal affairs; the city manager movement has grown tremendously and the public conscience has been quickened in many ways.

With regard to our city properties, a book might well be written on 'The Shame of Our Utilities,' dealing especially with our sewage properties. Of all municipal utility systems, water supply, sewage, electric lighting, gas, garbage, etc., the water and sewer systems were long ago recognized as the most important because of their direct influence upon health. For this reason approval of plans for proposed water and sewer systems was made a function of state boards of health, and more or less power was delegated to them with regard to their operation. The situation with respect to our water supplies is now fairly good, but the condition of our sewerage facilities is in many places deplorable.

Sewerage works include the sewers for collecting the sewage, pumping stations for lifting it where necessary, and the treatment plants for changing its character before discharging it. Greater use of rivers as a source of water supply and their increased pollution due to more and more congestion of population, have made necessary the development of methods of purification of water and treatment of sewage; and drastic laws have been passed in several states to prevent pollution of streams. It is true that there are problems still to be solved as regards the treatment of sewage, but much has been accomplished, and methods are now available producing satisfactory results in most cases, especially when the problem is not complicated by the presence of trade wastes.

The design of the collecting system of sewers has

*Paper read at Joint Meeting of California Sewage Works Association with Department of Engineers, Councilmen and Street Superintendents of League of California Municipalities, San Bernardino, October 9, 1928.

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been fairly well worked out in the past, although many cities have systems which have just 'growed' like Topsy, without any comprehensive plan, and are now overloaded, burdened with unnecessary infiltration water, and imperfect in various ways. Pumping of sewage often becomes necessary due to the lay of the ground and design of treatment plants, and great strides have been made in design of sewage pumps during the last five years; pumping, however, entails a continuous expense for power, attendance and repairs. Treatment of sewage has been studied for many years, the work of the Massachusetts Board of Health for the last forty years being especially noteworthy. Problems of treatment are not all solved, but much is being accomplished along this line also. However, it is the cost of operating the treatment plant which needs special attention with regard to financing.

At the present time there are probably at least 2500 sewage treatment plants in the United States, representing an investment which has been estimated at more than $100,000,000. California now has over 180 sewage treatment plants of all kinds, adequate and inadequate, which is probably more than any other state with two exceptions. Consequently the subject of financing sewer operation and maintenance should be one of especial interest to this State.

It is frequently not difficult to arouse the interest of the public sufficiently in the need for the construction of sewers and sewage treatment plants so that funds will be secured. But as to proper operation of the plant after its construction—'aye, there's the rub.' Enthusiasm frequently abates as far as the public is concerned, and changes in city officials result in lack of interest and neglect. Exceptions to this general situation do exist, especially where nuisance to sight or smell, or menace to health would be unbearable. The fear of damage suits due to nuisances or danger to health, is frequently the main incentive toward proper operation.

A committee of the American Society of Civil Engineers has recently made a survey of the situation through the boards of health of states and cities, and this investigation showed by far the major portion of the sewage treatment plants to be poorly operated. Of 90 plants in Kansas, the State Sanitary Engineer re-

ports that only 40 per cent receive adequate attention where cities are trying to get satisfactory results, although not necessarily succeeding; 37 per cent receive some but insufficient attention; and 23 per cent are neglected or not operated at all. And Kansas is no exception.

Why should a city employ capable engineers to design a plant, let the construction to a responsible contractor to build, and then after the plant is completed and the investment made, turn the plant over to an uninterested or already overworked official to operate? It has frequently been remarked that a poorly designed plant with a capable operator may produce much better results than a well designed plant with an incapable operator. In other words, the particular type of plant and equipment is of less importance than a genuine effort toward proper operation. Whether a plant is successful or not, depends in greatest measure on the skill and intelligence with which it is operated. Failure to secure the results possible with a given plant, means wasted investment.

In order to secure proper operation of sewerage works, attention must be given to two interrelated matters: (1) personnel, and (2) finance. Responsibility for satisfactory operation does not rest primarily upon the State Board of Health; as frequently neither the power nor funds are available to the board to force or assist proper operation. The fundamental reason for the failure of most sewage treatment plants, is the failure of the public to meet its civic responsibility by a sustained interest in the city business; the immediate reason, however, may be the apathy of the city officials, including the man to whom the plant has been turned over to run.

Personnel is an inclusive term involving city engineer, plant superintendent, analysts, operators, and common labor. Some types of plant require continuous supervision by technically trained operators, and others need only part-time supervision by an ordinarily intelligent man, properly instructed by sanitary engineers or the State Board of Health. No plant can be entirely automatic (although some are so-called); all plants need regular, if not continuous attention. Reasons for failure of personnel are lack of training, ignorance, carelessness, or neglect. Carelessness and

neglect are inexcusable, but lack of training and knowledge can often be remedied. Associations, such as the California Sewage Works Association, will be of great benefit in the exchange of ideas and experience, and the instruction of operators regarding the technical phases of operation. However, the presence of operators is necessary in order that the benefit be secured, and city councils should make it possible for them to attend, and insist upon their attendance.

Personnel for operation should be of the quality needed by the individual plant; willingness to learn and ambition to secure the requisite knowledge being important. Sewage disposal plants cannot be expected to run themselves with occasionally a little moral support from an uninterested official. If sanitary engineers who design such plants were more often hired with other factors besides the amount of fee as the controlling basis of selection, they could agree to furnish advice and assistance during the first year or two of a plant's life, or while it is getting into operating condition and operators are being trained. Under the present conditions of inadequate appropriation to the State Board of Health, inspections by a representative of the board have been possible only on the average as follows: septic tanks once in 2.4 years; Imhoff tanks, 2.0 years, sewer farms, 1.8 years; filters, 1.2 years; disinfection plants, 0.8 year; activated sludge plants, 0.2 year. This is a condition far from satisfactory.

A considerable investment in a treatment plant deserves a trained manager. His compensation should be commensurate with his responsibilities, and then better men would be induced to seek such jobs. In order to get satisfactory personnel, adequate compensation must be provided. The Ohio State Board of Health with the hearty support of the Governor, has adopted the policy of withholding permission to construct plants until cities make proper financial provision for their operation. Too often has the financing of construction marked the high tide of public interest, with no subsequent provision for operation and maintenance.

Costs of operation and maintenance include the repairs, cleaning, and flushing of the sewer system, and repairs, power, supervision, and common labor for pumping and treatment plants. Treatment costs vary with size, type, and location of plant, but also with quality of sewage

treated and extent to which treatment must be carried. By their failure to provide adequate funds for the payment of proper personnel and other operating charges, cities reduce or nullify the value of their investment in construction.

Methods of securing funds for operation and maintenance of sewerage facilities are mainly two: (1) allotment from the general fund; (2) charging a sewer rental. The operation of the vast majority of municipally-owned systems throughout the country, is financed from the general fund. In some states cities have been confined within certain statutory limits as to expenditures for construction and operation; in all states there exists the need of convincing local officials of the advisability of providing adequate funds for operation. Too often the sole aim of city officials seems to be to keep the tax rate low, with its inevitable result. A disadvantage of financing sewer operation out of the general tax levy is that all property has to pay, whether directly benefited or not. In most cities some areas are not sewered, and in all cities some areas are not built up; such areas would hardly seem to be benefited by operation of sewerage, even though they may be by its construction. This method has been tried and found wanting in most places, and for one reason or another has failed to result in adequate funds for efficient operation.

The second method, charging a sewer rental, is the one most recently tried, and is giving considerable promise. Water, electricity, and gas cost money to produce and distribute, and garbage costs money to collect and dispose of, and the public understands the necessity of charging therefor. Why should sewage collection and disposal be a non-revenue producing utility any more than these others? In general the public has considered sewerage as a non-revenue producing property. Where no treatment plant is used and the cost of operating the sewers is nominal, such an attitude may be justified. In scattered instances charges have been made for sewer service, chiefly in cities where the construction of privately-owned systems has been allowed, such as several cities in New Jersey, Texas, etc. Rates in most cases were established by franchise, and in some have been reviewed by public utility commissions according to the same general principles applying to other utilities.

Rarely, however, have municipalities charged for service up to four years ago.

A sewer rental charge is a direct tax levied on properties served in accordance with the value of the service. Benefit is enjoyed by developed properties abutting upon and using the sewers, and it is their connection to and use of the system which gives rise to costs of operation and maintenance. Any charge for service should of course not tend to prevent use, and a regulation requiring use for sake of health may be needed.

It is said that New Jersey cities, under the home rule act of 1917, have had the power to charge a sewer rental, although about the only use which has been made of it is in the case of purchase of privately-owned systems by cities which have continued a charge after purchase. The first specific law of this kind was proposed by the State Board of Health and was passed by the Ohio Legislature April 5, 1923, and went into effect July 30, 1923, without the signature of the Governor; this law being commonly known as the Sewer Rental Law. The law is a permissive and not a mandatory one, and is intended to put the sewer department on much the same basis as the water department, so that the sewerage system may be operated on a self-supporting basis also. This act permits municipalities to establish just and equitable rates for use of sewers, allows rates to be changed when advisable, makes the charge a lien on property served, and provides for unpaid charges to be collected with taxes; the act also provides for making of regulations necessary for safe, economical, and efficient management; it specifies that funds shall be deposited weekly in a separate fund, that the fund be used for maintenance, operation, and repair; that any surplus may be used for enlargement or replacement, interest on bonds, or sinking fund; but prohibits its use for extensions to unsewered areas.

Since the passage of this act Ohio cities are passing sewer rental ordinances with commendable rapidity; one city passed an ordinance in 1924, three in 1925, one in 1926, two in 1927, and seven so far in 1928, with several others considering it. It seems to appeal to city officials that sewerage should be on a utility basis, and the attitude of the public is said to be even more favorable since its adoption than prior thereto. The cities

using this method range in population from 1000 to 210,000. In these cities the cost of operation of the sewer system itself ranges from $0.01 to $0.88 per capita per year, and the cost of operating the sewage treatment plant ranges from $0.22 to $1.07. (See Table 1).

TABLE 1

COST OF SEWER MAINTENANCE IN OHIO CITIES
(HAVING SEWER RENTAL ORDINANCES)

CITY	PEOPLE SERVED	TYPE OF DISPOSAL PLANT	TECHNICAL SUPERVISION	ANNUAL COST OF OPERATING SEWER SYSTEM Total	ANNUAL COST OF OPERATING SEWER SYSTEM Per Capita	ANNUAL COST OF OPERATING DISPOSAL PLANT Total	ANNUAL COST OF OPERATING DISPOSAL PLANT Per Capita	ANNUAL REVENUE FROM SEWER RENTAL
BELLEFONTAINE	7500	ST, CB	Part Time	$1000	.13	$3000	.40	$ 2000
OXFORD	3000	IT, TF, FST	" "	2000	.67	2000	.67	6000
E. PALESTINE	5000	IT	" "	Very	Little	1500	.30	2600
BREWSTER		IT						
ANDOVER	1000	ST, SF		10	.01	400	.40	1100
DELAWARE	8750	IT, TF, MC	" "	2000	.23	9000	1.03	11000
LEETONIA		MC, SSD, TF	" "					
CHARDON	1700	IT, CB, SF	" "	1500	.88	1500	.88	2600
DAYTON	210,000	FS, IT	Full Time	41813	.20	Began Mar. 1928		111789 *
KENMORE	20,000	none	—					
MINERVA	3000		None			3200	1.07	
WESTERVILLE	3000	IT, CB	"			650	.22	
MARYSVILLE		IT, CB, SF						
SALEM	10000		Part Time	300	.03	11000	1.10	

LEGEND - Type of Disposal Plant
F.S. = Fine Screens
ST = Septic Tank (with sludge bed)
IT = Imhoff " (" " ")
MC = Mechanical Clarifier
SSD = Separate sludge digestion
CB = Contact bed
TF = Trickling filter
SF = Sand filter
FST = Final settling tank
* Feb. 1 — Sept. 15
AS = Activated sludge

According to the Chio Board of Health, conditions were very bad; of the eighty sewage treatment plants of various kinds less than 10 per cent had technical supervision, less than 20 per cent gave satisfactory service; plants were built without funds being assured for operation, current revenues were insufficient to provide satisfactory operation, amount of money available from taxation was limited by statute, while damages levied on account of neglect were unlimited because a preferred charge against the city. Escape from damages and injunction suits was often an incentive to construction without provision being thought of for operation. The Board of Health finally began to refuse approval of plants unless assured that funds for satisfactory operation were provided. The need for skilled operation after construction is gradually being realized, especially in the larger cities where the investment is

large; but in the smaller cities the salary for trained operators seems high in proportion to other local salaries.

The ordinances adopted by Ohio cities use two different bases for determination of rental: (1) flat rate; (2) water consumption; and occasionally a combination of the two. On the flat rate basis the charge is (a) a simple lump sum per sewer connection; (b) a simple lump sum for residences per 'group of conveniences' (those ordinarily and usually found in a single family dwelling); and a different rate for factories, stores, hotels, etc., per 'group of conveniences' (each individual set in a battery), with a water consumption charge for special industries contributing large amounts of sewage; (c) a complicated schedule for dwellings, hotels, stores, factories, churches, etc. The flat rate method seems to be most used for the smaller cities, or for cases where not all the water services are metered, or where the water property is owned by a private company and meter readings are not available to the city. On the water consumption basis the charge is (a) a simple rate regardless of amount used; (b) a graduated scale of rates depending on amount used; an estimate being allowed if no meter is installed or the user has a private water supply; a minimum charge is also provided.

Sewer rental is made payable every three, six, or twelve months; in three cases a discount for prompt payment is provided, and in five cases a penalty is added for non-payment. In most cases if the rental is not paid, it is certified to the county auditor to place on the tax duplicate and be collected as other municipal taxes; in one case if payment is not made within thirty days the connection to the sewer shall be discontinued, a rather amusing provision in view of the desirability of sewers from the health standpoint as well as the difficulty and expense of disconnecting. Disconnection of water service would be more logical and a sure method of enforcement. The actual minimum charge for the average residence runs from $1 (admittedly inadequate where used) to $8 per year, averaging from $4 to $5, or roughly about $1 per capita per year. (See Table 2 on next page.)

The testimony of city clerks in cities collecting a sewer rental may be interesting. Bellefontaine, ordinance in effect four and one-half years—"There are various attitudes of the public; some people do not un-

derstand why, after they have been assessed for the installation of the sewer, they should be charged for the use of it; the explanation given them is that it is just like buying an automobile, it is theirs to use after purchase, but they must pay for the operation of it and a

TABLE 2

SEWER RENTAL ORDINANCES IN EFFECT IN OHIO

CITY	RENTAL ORDINANCE IN EFFECT	RENTAL PAYABLE	RESIDENCE ANNUAL MINIMUM CHARGE	BASIS OF CHARGE	DISCOUNT FOR PROMPT PAYMENT	PENALTY FOR NON-PAYMENT	METHOD OF ENFORCING PAYMENT
BELLEFONTAINE	May 1924	Annually	$1	Flat			Taxes
OXFORD	Jan. 1925	Quarterly	5	Water Con.			
E. PALESTINE	Apr. 1925	"	2	Flat			Taxes
BREWSTER	July 1925	"	4	Flat		10 %	Stop Service
ANDOVER	July 1926						
DELAWARE	Oct. 1927	"	4	Flat		10 %	Taxes
LEETONIA	Oct. 1927	"	4	Flat			Taxes
CHARDON	Jan. 1928		6	Flat			
DAYTON	Feb. 1928	"	4	Water Con.	5 %	5 %	Taxes
KENMORE	Mch. 1928	"	8	Water Con.			Taxes
MINERVA	Apr. 1928	"	4	Flat		10 %	Taxes
WESTERVILLE	May 1928	"	6	Water Con.	10 %		Taxes
MARYSVILLE	Dec. 1928	Semi-Ann.	4	Flat		10 %	Taxes
SALEM	June 1928	Quarterly	4	Water Con.	10 %		Taxes

tax to use it. The majority of people understand the reason for the rental and are broad-minded enough to see the justice of it." Oxford, ordinance in effect three and three-quarters years—"We have experienced the best of satisfaction from this method. The public mind has come to realize that this system of financing is a great improvement over the old method of tax percentage. Our sewer department is a free and better body with its own funds, and the general attitude of the people is that their health is safeguarded against any of the dangers that arise from inadequate sanitary facilities. It is a fact that sanitary conditions are far better than at any time in the past. We have come to think that this is the only way to handle this department and that there should be no hesitation in urging any community to adopt this system." East Palestine, ordinance in effect three and one-half years—

"Attitude of public was somewhat divided; however since ordinance is in effect the objection has died a natural death and citizens pay this tax as naturally as for water, light, etc. It is working finely and plant is self-supporting." Delaware, ordinance in effect one year—"The city was facing a financial shortage and the general fund was unable to take care of this additional drain; the sewer rental ordinance seemed to be the most equitable means of providing funds. An estimated 95 per cent of the people coming to pay their rental, agree that it is the best and most equitable way of collecting this money, and no one has been able to suggest a better method." Chardon, ordinance in effect nine months —"While this is a small community it was necessary to provide some means to take care of the cost of operating the disposal plant, and this means has proved very satisfactory. We have little trouble in collecting this rental; at first there was considerable opposition but something had to be done and the ordinance was passed by unanimous vote and is working finely." Sebring, now considering an ordinance—"The general public so far seems to be in favor of this method, the basis of water consumption being apparently the more favored." Marysville, ordinance to go into effect Dec. 1 next—"The attitude of the public seems to be favorable; there have been no arguments in the press or before the council." Xenia—"The law is unquestionably a good one and the time may come when we will avail ourselves of this income." Salem, ordinance passed recently—"In regard to the attitude of the public, after explanations are set forth, they believe that this sewer rental is justified."

In the State of Texas approximately half the smaller towns charge for sewer service, not in conformity with any special law but in the absence of any law prohibiting such a charge. The chief sanitary engineer reports that this method is found to be a most convenient one for providing funds for maintenance, operation, and extension of sewers and sewage disposal plants. Experience in those towns has been that people connect with sewers just as freely as in the towns where no charge is made, and hence the charge does not retard the use of the sewers. The actual charge varies from $1 to $18 per year, collection being made

at the same time with the water bills and usually enforced by discontinuance of water service. Several cities have acquired their sewers from private owners and pay the cost out of sewer rent; some cities finance extensions out of this fund, one used it to pay operating expenses of its health department. Most of the larger cities have no sewer rental charge, but Dallas is now considering passing such an ordinance, thus hoping to secure enough revenue to construct additional units at the treatment plant. A number of private sewer systems exist in the State, and their charge varies from $12 to $42 per year; actual rates have usually been much reduced when private systems have been purchased by cities, but the method of charging sewer rental has been retained.

In the State of Massachusetts the cost of sewer maintenance is generally paid out of the tax levy, but the general laws provide that any municipality (except Boston) may make just and equitable annual charges for the use of a common sewer. In a number of cases an annual rental charge based largely on the water bills has been established, instances being Athol, Attleboro, Brockton, Framingham, Nateck.

However, in a case involving an act giving the street commissioners of Boston power to determine just and equitable sewerage charges to be paid for the construction, maintenance, and operation of the sewerage works, the Massachusetts Supreme Court held the act unconstitutional on several grounds. In this case the court expressed the opinion that in rightfully assessing benefits on abutting property when the sewers were constructed, it was assumed that they would be kept in operation for the benefit of the public, and that property owners would only be called upon to contribute as general taxpayers their proper share of the expenses of operating then.

In the State of Pennsylvania an act relative to boroughs was passed in 1917, specifying that 'the council of the borough may provide by ordinance for the collection of an annual rental or charge for the use of the sewer system from the owners of property served by it; such annual rental shall not exceed the amount expended in the maintenance, repair, alteration, inspection, depreciation, or other expense in relation thereto.' In 1925 the Pennsylvania Legislature passed an act

relative to cities of the third class, stating that 'cities may provide by ordinance for the collection of an annual rental or charge for the use of the sewer system or sewage disposal plants from the owners of property served by it, the amount collected not to exceed the amount expended in operation, maintenance, repair, alteration, inspection, depreciation, or other expenses in relation to such sewer, sewer system, or sewage disposal plant.' The need was thus recognized in Pennsylvania and, although no sewer rental ordinances have been passed as yet, they are being considered in several cities. The State Board of Health recently suggested it to a city near Harrisburg as a proper method of financing.

In the State of Michigan bills were passed which became effective in August, 1927, providing for the construction, operation and maintenance of sewage disposal plants and sewers as a utility, allowing necessary rules and regulations to be made governing their use and operation, permitting the fixing and collecting of just and equitable charges for the use of such disposal plant and system, and making any unpaid charges a lien against the property and collectible with taxes. There are as yet no municipalities operating under this law, but several are reported to be preparing to do so as soon as their disposal plants are completed. Many Michigan localities are keenly interested in this plan, and it is expected that in quite a number of them the question of establishing sewage disposal on a utility basis will be submitted to the voters in April, 1929. The city of Grand Rapids has gone quite extensively into the question of rate-making, and has decided to use a two-part rate with a service charge, based on size of water meter, and a sliding scale using water consumption as a measure of sewage flow. In this way people whose houses are closed part of the time continue to pay their share of the investment. In Flint the rate is considered to be applicable to maintenance and operation costs only, payable as a percentage added to the water bill.

In California practically all sewer systems are municipally owned. Various methods of securing funds for construction are provided in the various improvement acts, but no special method of securing funds for operation is provided. These costs of operation

are financed out of the general fund for which a limit in the tax rate of $1 per hundred dollars' valuation is fixed by statute. Where a menace to health can be shown, maintenance of the system can be provided for by special direct assessment. The dollar tax rate is sometimes given as an excuse for neglecting proper operation, and some other method of providing for operation and maintenance would often be appreciated, especially by cities where rather complete treatment of sewage is necessary at considerable cost. Sanitary districts under the 1923 act are empowered to maintain sewers and sewage works, but a limit of fifteen cents per hundred dollars' valuation is fixed for their maintenance and operation and other expenses of the district, and this is sometimes insufficient. The 1927 act providing for Sewer Maintenance Districts in unincorporated territory of counties, allows the board of supervisors to form and manage such districts, and to levy a tax to defray cost.

Records from several cities in California show that operation of the sewer system itself ranges from $0.04 to $1.08 per capita per year, and the cost of operating the sewage treatment plants from $0.04 to $1.71. Actual costs of operation are very different, even for similar types of treatment, depending upon the necessity of pumping the sewage, size of plant, adequacy of supervision, and other factors. Averages show fine screening to cost the least, then sedimentation, then filters, and activated sludge the most, which is to be expected, being in the order of efficiency of process. (See Table 3).

In summarizing this paper the following points may be noted: (1) Many sewage treatment plants are neglected entirely, or inefficiently operated. (2) Skillful operation is just as necessary for good results as wise designing and careful construction. (3) Proper financing of operation and maintenance is necessary in providing skillful supervision. (4) The recent sewer rental laws of Ohio, Michigan, and other states, seem to provide a successful method of financing. (5) A sewer rental law in California might be welcomed by many cities as a means of providing necessary funds for efficient operation.

Some may be interested in the text of the sewer

rental laws in other states; those for Ohio and Michigan are appended:

OHIO SEWER RENTAL LAW

(Section numbers, Ohio General Code, Effective July 30, 1923.)

Council May by Ordinances Establish Rates or Charges of Rent to be Paid City or Village—Sec. 3891-1. The council of any city or village which has installed or is installing sewerage, a system of sewerage, sewage pumping works or sewage treatment or disposal works for public use, may by ordinance establish just and equitable rates or charges of rents to be paid to such

TABLE 3

COST OF SEWER MAINTENANCE IN CALIFORNIA

CITY	PEOPLE SERVED	TYPE OF DISPOSAL PLANT	TECHNICAL SUPERVISION	ANNUAL COST OF OPERATING SEWER SYSTEM Total	Per Capita	ANNUAL COST OF OPERATING DISPOSAL PLANT Total	Per Capita	ANNUAL INCOME RECEIVED
LOS ANGELES	1135000	FS	Full Time	$195000	.17	$45000	.04	
LONG BEACH	120000	FS	" "	36191	.30	21578	.18	
SANTA ANA	35000	FS	" "	7450	.21	7800	.22	
SANTA BARBARA	35000	FS	None	4127	.12	8794	.25	
STOCKTON	29000	FS	Full Time	10000	.35	13359	.46	
STOCKTON	29000	IT	"	10000	.35	10923	.38	
VISALIA	7000	IT	Part Time	3000	.43	2000	.29	$1800 farm rental
WHITTIER	17000	FS, IT, TF	None	2800	.16	3600	.21	$600 sludge
ROSEVILLE	6000	MC, SSD, D	Part Time	6500	1.08	2500	.42	
MADERA	4500	IT, TF	None	235	.05	2506	.33	
DINUBA	3300	IT, TF	"			1847	.36	
KINGSBURG	1500	SF, IT, TF	"			2086	1.39	
MORGAN HILL	750	IT, TF	None			250	.33	
CORONA	5000	SF, IT, TF	Part Time			1661	.33	$60000 sludge
PASADENA	100000	AS	Full "	9000	.09	171345	1.71	
LODI	8000	AS	" "	1778	.22	10146	1.27	
POMONA	7500	AS	" "	4000	.53	8500	1.13	$7650 water
DUNSMUIR	5000	AS	Part "	200	.04	3970	.79	

LEGEND-TYPE OF DISPOSAL PLANT

FS = Fine screens; S.F = sand filter; IT = Imhoff tanks; AS = activated sludge; MC = mechanical clarifier; TF = trickling filter; D = disinfection; SSD = separate sludge digestion

city or village for the use of such sewerage, a system of sewerage, sewage pumping works or sewage treatment or disposal works by every person, firm or corporation whose premises are served by a connection to such sewerage, system of sewerage, sewage pumping works or sewage treatment or disposal works. Such charges shall constitute a lien upon the property served by such connection and if not paid when due shall be collected in the same manner as other city and village

taxes. The council may change such rates or charges from time to time as may be deemed advisable. Provided, however, that in a municipality operating under a municipal charter the council or other legislative body may establish the schedule of rates herein authorized and provide for its administration by designating the department or officer of the municipality to be charged with the enforcement of the provisions of this act.

Director of Public Service; General Duties—Sec. 3891-2. In a city the director of public service shall manage, conduct and control the sewerage system and sewage pumping, treatment and disposal works and when the council has established a schedule of rates or charges of rents for their use shall collect sewer rentals, and he shall appoint the necessary officers and agents for such purposes.

Board of Trustees of Public Affairs Shall Manage and Control Sewerage System, Etc.—Sec. 3891-3. When the council of a village has established a schedule of rates or charges of rents for the use of the sewerage system and sewage pumping, treatment and disposal works, the board of trustees of public affairs shall manage, conduct and control such sewerage system and sewage pumping, treatment and disposal works and shall collect sewer rentals and shall appoint necessary officers and agents for such purposes; and shall assume all duties, in relation to sewers, imposed upon the street commissioner by Section 4364 of the General Code, whereupon the street commissioner shall be relieved of such duties.

By-Laws and Regulations—Sec. 3891-4. The director of public service and the board of trustees of public affairs may make such by-laws and regulations as may be deemed necessary for the safe, economical and efficient management and protection of the sewerage system and sewage pumping treatment and disposal works; and for the construction and use of house sewers and connections to the sewerage system. Such by-laws and regulations shall have the same force and effect as ordinances when not repugnant thereto or to the constitution or laws of the State.

Reception and Distribution of Funds Derived from Sewer Rentals—Sec. 3891-5. The funds received from the collection of sewer rentals shall be deposited

weekly with the treasurer of the corporation. Money so deposited shall be kept as a separate and distinct fund and shall be known as the sewer fund. When appropriated by council, it shall be subject to the order of the director of public service of a city or board of trustees of public affairs of a village. Such director or board shall sign all orders drawn on the treasurer of the corporation against such fund. This fund shall be used for the payment of the cost of the management, maintenance, operation and repair of the sewerage system and sewage pumping, treatment and disposal works and any surplus in such fund may be used for the enlargement or replacement of the same and for the payment of the interest on any debt incurred for the construction of such sewerage system and sewage pumping, treatment and disposal works, and for the creation of a sinking fund for the payment of such debt, but shall not be used for the extension of a sewerage system to serve unsewered areas or for any other purpose whatsoever.

When Board Shall Be Established—Sec. 4357. In each village in which water works, an electric light plant, artificial or natural gas plant, or other similar public utility is situated, or when council orders water works, an electric light plant, natural or artificial gas plant, or other similar public utility, to be constructed, or to be leased or purchased from any individual, company or corporation, or when the council shall have determined to establish a schedule of rates or charges of rents for use of the sewerage system and sewage pumping, treatment and disposal works of the village, council shall establish at such time a board of trustees of public affairs for the village, which shall consist of three members, residents of the village, who shall be each elected for a term of two years.

MICHIGAN SEWER RENTAL LAW

(Act 320, Public Acts of 1927.
Effective August, 1927.)

Sec. 1. Any city or village in this State is hereby authorized to own, acquire, construct, equip and operate either within or without the corporate limits of such municipality a plant or plants for the treatment, purification and disposal in a sanitary manner, approved by the State Department of Health, of the liquid and solid wastes, sewage and night soil of such

municipality. It shall have authority to acquire by gift, grant, purchase or condemnation necessary lands therefor, either within or without the corporate limits of such municipality. For the purpose of acquiring property for the uses herein mentioned such municipalities may invoke and shall have all of the rights, powers and privileges granted to 'public corporations' under the provisions of Act No. 149 of the Public Acts of 1911, being Sections 353 to 373, inclusive of the Compiled Laws of 1915 as amended, and which shall be in addition to any powers granted such municipality by its charter.

Sec. 2. Such sewage disposal plant and system shall be considered a public utility within the meaning of any constitutional or statutory provision of this State for the purpose of purchasing, owning, operating, constructing and equipping such sewage disposal plant and system. A municipality may issue mortgage bonds therefor beyond the general limits of the bonded indebtedness prescribed by law except as hereinafter provided. Such mortgage bonds as provided in this section shall not impose any general liability upon the municipality but shall be secured only on the property and revenues as hereinafter provided of such utility including a franchise stating the terms upon which, in case of foreclosure, the purchaser may operate the same, which franchise shall in no case extend for a longer period than twenty years from the date of the sale thereof on foreclosure. Such mortgage bonds shall be sold for not less than par; bear interest at a rate not to exceed 6 per cent per annum and the total amount thereof shall not exceed 60 per cent of the original cost of the utility except as hereinafter provided. No bonds shall be issued as general obligations of the municipality except upon a three-fifths affirmative vote of the qualified electors of such municipality and except as hereinafter provided, nor in excess of 3 per cent of the assessed valuation of the real and personal property of such municipality as shown by the last preceding tax roll.

Sec. 3. The legislative body of any such municipality may create a separate board or may designate certain officials of the municipality to have the supervision and control of such sewage disposal plant. The legislative body or such board may make all necessary rules and regulations governing the use, operation and con-

trol thereof. The legislative body may establish just and equitable rates or charges to be paid to it for the use of such disposal plant and system by each person, firm or corporation whose premises are served thereby. If the service charge so established is not paid when due, such sum may be recovered by the municipality in an action of assumpsit, or it may be certified to the tax assessor and assessed against the premises served, and collected or returned in the same manner as other municipal taxes are certified, assessed, collected and returned.

Sec. 4. Bonds which are issued and secured by a mortgage on the utility as hereinbefore provided shall not be a general obligation of the municipality, but shall be paid only out of the revenues received from the service charges as provided in the preceding section, or from a sale of the property and franchises under a foreclosure of the mortgage. If a service rate is charged to be paid as herein provided, such portion thereof as may be deemed sufficient shall be set aside as a sinking fund for the payment of the interest on said bonds, and the principal thereof at maturity.

Sec. 5. Any municipality as herein mentioned, instead of owning and operating a sewer system and sewage disposal plant, as herein provided, may grant a franchise for a period not to exceed thirty years to any private corporation organized under, or authorized by the laws of this State to engage in such business, to build, construct, own and operate a sewage disposal plant for the purpose of receiving and treating sewage and night soil as hereinbefore mentioned from such municipality. Such franchise may authorize the corporation to charge each person, firm or corporation owning property from which such sewage is received such a fee therefor as may be determined to be reasonable by the public utilities commission of this State, upon proper application made either by such corporation or the municipality, and after a hearing thereon. Such franchise may also grant to the corporation the right and privilege to lay all such necessary, intercepting and other sewers and connecting pipes in the streets and public alleys of the municipality as may be necessary to receive and conduct the sewage to the disposal plant and under such reasonable rules, regu-

lations and supervision as may be established by the municipality.

Sec. 6. Any such municipality may enter into a contract with any corporation organized under or authorized by the laws of this State to engage in the business herein mentioned, to receive and treat in the manner hereinbefore mentioned the sewage and night soil thereof. Such contract may authorize the corporation to charge the owners of the premises served such a service rate therefor as the Public Utilities Commission of this State may determine to be just and reasonable, or the municipality may contract to pay the said corporation a flat rate for such service, and pay therefor out of its general fund or assess the owners of the property served a reasonable charge therefor to be collected as hereinbefore provided and pay into a fund to be used to defray such contract charges.

Sec. 7. Whenever a court of competent jurisdiction in this State shall have ordered the installation of a sewage disposal system in any municipality herein mentioned, and the plans therefor shall have been prepared, and approved by the State Commissioner of Health, the legislative body thereof shall have authority to issue and sell the necessary bonds for the construction and installation thereof, including the disposal plant and such intercepting and other sewers as may be necessary to permit the effective operation of such system; such bonds to draw interest at not to exceed six per cent per annum, and payable in not to exceed thirty years from the date of issuance; the legislative body to determine the denomination of said bonds and the date, time and manner of payment. The amount of such bonds either issued or outstanding shall not be included in the amount of bonds which the said municipality may be authorized to issue under its charter or any statute of this State. Any municipality issuing bonds hereunder in excess of the limit of the authorized bonded indebtedness fixed by its charter, or by any other statute, the principal and interest of which are not to be paid out of funds created from service charge, as hereinbefore provided, may raise such a sum annually by taxation as its legislative body may deem necessary to pay interest on such bonds, and to create a sinking fund to pay the principal thereof as it falls due, such annual amount

may be in excess of the authorized annual tax rate fixed by its charter or other law. Except as otherwise provided in this act, all bonds issued hereunder shall be issued and sold in conformity to the provisions of Act No. 273 of the Public Acts of 1925 or as it may be hereafter amended.

Sec. 8. Whenever an order shall have been made by any court of competent jurisdiction, as hereinbefore provided, the fact that such order was issued shall be recited in the official minutes of the legislative body. The said body shall thereupon require that plans and specifications be prepared of such sewage disposal system, including the necessary storm and sanitary sewers, which plans when submitted and approved by the legislative body shall be submitted thereafter to the State Commissioner of Health for his approval. If such plans are so approved, the legislative body shall thereupon authorize the issuance and sale of the necessary bonds to establish the proposed system.

Sec. 9. The authority hereby given shall be in addition to and not in derogation of any power existing in any city or village under any charter provisions which it may now have or may hereafter adopt: Provided, that this act shall not apply to any city organized under the provisions of Act No. 279 of the Public Acts of 1909 until such city shall have adopted the provisions hereof in the manner provided in said Act No. 279 of the Public Acts of 1909 for amending the charter thereof.

Sec. 10. Proceedings under this act shall be taken only in a court of competent jurisdiction in the county in which the proposed sewage disposal system is to be constructed.

Sec. 11. Act No. 2 of the Public Acts of the Extra Session of 1926 and any other acts or parts of acts inconsistent herewith are hereby repealed.

DISCUSSION

Mr. Gillespie emphasized that the paper struck at the very root of better operations of sewers and disposal works; for what use is it to know what ought to be done if the funds allotted do not allow it? Just as a practical proposition, with cities allowed only $1 per $100 tax for general purposes as is the case, some civic enterprise is slighted and almost invariably it is

the sewer system. Of course, not all cities would avail themselves of a sewer-rental enabling act, but some would if they had a chance and the number using it would swell.

Mr. Perry stated that Prof. Reynolds had given an excellent paper and was entitled to our thanks. He described the situation with which he had to deal in Marin county.

Mr. Schuyler stated that the financing of sewer maintenance in our cities and towns in California had in most cases been by means of setting aside so much from the city budget, and as this comes from the tax rate it is frequently cut down along with other things. He does not know of an instance in any city or town in the State where there is an adequate sum for sewer maintenance, and it is high time that we find a new method of financing this important city function.

Mr. Warburton, representing the town of Madera, stated that they were facing the problem in just the same way as any small town. In their case the prob-

A Good Example of a Properly Designed and Operated Sprinkling Filter and Final Settling Tank, at Madera, California.
F. A. Nikirk, Designing Engineer

lem is so serious that the council some six weeks before the meeting of the convention started investigating with the idea of having a special sewer charge made. Such a charge was made in Madera up to seven or eight years ago, when a few disgruntled citizens took it into the courts and succeeded in defeating the city in the collection of 50 cents per month from sewer users. The city took it to the Appellate Court and again lost. The former attorney for the disgruntled

citizens is now city attorney and is working on the problem of getting a charge which will be upheld by the court. He suggested referring the paper to the legislative committee with the idea of getting a bill before the next Legislature.

Mr. Knowlton remarked that a year ago two subjects had been considered by the League, one in reference to research and the other an enabling act which would admit of proper funds being provided for sewer maintenance. It was thought at that time best to take up one thing at a time, but he believed it proper to appoint a committee because of the evident interest in financing sewer maintenance.

Following a motion duly seconded and carried, the chairman appointed a committee to take up the matter of a sewer rental bill to be placed before the next Legislature. The members of the committee follow: Thos. Warburton, W. J. Locke, F. A. Batty.

RESOLUTION CONCERNING SEWER RENTAL BILL

Whereas proper operation and maintenance of sewer systems and sewage disposal plants is essential to successful results, and

Whereas many sewer systems and sewage disposal plants in California are being inefficiently operated through lack of proper financing, and

Whereas other municipal utilities including water works, electric plants, gas works and garbage collection and disposal plants are operated on a self-supporting basis with separate charges for the service, and

Whereas the recent permissive sewer rental laws of Ohio, Pennsylvania, Michigan and other states seem to provide a successful and satisfactory method of financing the operation and maintenance of sewer systems and sewage disposal plants

Now therefore be it resolved that the California Sewage Works Association in convention assembled does hereby instruct its Legislative Committee to prepare a suitable bill for submission to the next session of the Legislature permitting Municipalities to establish just and equitable rates or charges for the use of sewers and sewage disposal plants.

Know Your Sewage*

By Clyde C. Kennedy**

The most important element in connection with the solution of the general problem of sewage treatment and disposal is to bring about an understanding, on the part of the public officials in particular, and the citizenry in general, of the basic scientific principles upon which the intelligent solution of the problem rests. Knowledge of the biological and chemical principles upon which the ultimate destruction of sewage wastes depends, dates back less than fifty years. Only within the past fifteen years have the sciences of biology and chemistry and their inter-relationship been sufficiently understood so that the development of the processes of sewage treatment could proceed along sound scientific lines.

Sewage has been defined as 'the spent water supply of a community, together with the domestic and industrial wastes which it carries with it'. From the standpoint of the sanitary engineer, a dual problem is involved in its treatment; first, that of the solid portion which can be removed by the processes of screening or sedimentation, and second, that of the liquid portion, or effluent, containing all the finely divided, colloidal, or dissolved wastes which cannot be removed by the processes above enumerated.

In the design or operation of any municipal sewage disposal project, it must be recognized that the liquid portion must ultimately find its way into some stream, lake, or tidal body of water, or must be used in lieu of some stream for the irrigation of arid lands. It is now thoroughly understood that the capacity of a stream or tidal body of water to receive sewage, without nuisance, is dependent in large measure upon the ratio of the organic wastes in suspension and solution to the volume of oxygen dissolved in the diluting water body. Water, at ordinary temperatures, carries, approximately, eight parts of dissolved oxygen per million, and ordinary domestic sewage has a demand for oxygen of from 250 to 300 parts per million. It is, therefore, obvious that the minimum dilution for sewage of this character is in the ratio of one part of sewage to

* Paper read at Joint Meeting of California Sewage Works Association with Department of Engineers, Councilmen and Street Superintendents of League of California Municipalities, San Bernardino, October 9, 1928.

**Consulting Engineer, Call Building, San Francisco, Calif.

forty parts diluting water, if only the prevention of nuisance is to be sought.

The processes of modern sewage treatment have, as their fundamental purpose, the removal and ultimate oxidation of such portion of the wastes contained in the sewage as is necessary to so reduce the load on the diluting water body that its condition shall meet the standard required by its location and usage.

With this general conception of the purpose of sewage treatment in mind, it does not seem unreasonable to inaugurate programs of sewage treatment to prevent further encroachments on the capacity of the diluting water body, or to reclaim such water body when its use is so materially changed as to demand a higher standard of purity.

It is obvious that before any sewage works can be intelligently designed or operated, a thorough knowl-

A Foaming Imhoff Tank Induced by Paper Pulp Waste

edge of the characteristics of the sewage to be treated must be acquired. More than this, it is fundamental to the securing of any predetermined results, and it is to this phase, the discussion which follows will be directed.

The strength of a sewage may be measured, directly, by its biochemical oxygen demand, which means, in simple language, the amount of oxygen required to combine with the organic matter, or fuel, contained in the sewage; which combination is carried on through the agency of the biological life in the sewage. The reduction of biochemical demand means, therefore, a reduction in the organic matter, or fuel, the sewage contains. This is effected by preliminary treatment, removing the settleable or coarse solids; or by chemical or biochemical processes for removing the finely divided, colloidal, or soluble wastes; or by a combination of these processes.

Sewage from different communities and from different parts of the same community vary within such wide ranges, that studies of sewage properties must be made, embracing the physical, chemical, and biological characteristics, if the design and operation of sewage works be carried on intelligently.

From the standpoint of design, the physical qualities of the sewage are of interest to the engineer as they affect the choice of and capacity of the various plant units such as bar screens, mechanical screens, sedimentation and digestion tanks, and oxidation units. The physical factors which bear upon these are the volume of sewage flow and the amount of settleable and non-settleable solids. The rate of sewage flow, with its hourly, daily, and seasonal fluctuations, as well as the influence of storm conditions upon it, should be accurately known; yet, only too often, these data are lacking or meagre. Without such information, it is impossible to incorporate other knowledge of sewage characteristics intelligently into design. The nature and quantity of the settleable solids in the sewage determine, in large measure, the necessity for and capacity of the grit chamber, the area and spacing of the bar screens, are an important factor in the choice between the processes of screening and sedimentation, and determine the design of screens or the capacity of the settling tanks and digestion tanks, and the area of the sludge beds. Where high grade treatment is required, the quantity of non-settleable solids will greatly affect the size of the aeration units or the area of the filter beds.

The value of thorough chemical studies of the various elements affecting the sewage, to be handled, prior

to designing sewage works, is one that engineers are just beginning to appreciate. The difficulties that have arisen in the operation of high grade plants where unknown factors have disturbed and, in some cases, practically ruined the efficiency of the plant processes, have focussed attention on this phase of the problem. The tremendous increase in trade wastes of every description, particularly those from industries discharging chemical wastes, strongly acid or alkaline, or otherwise germicidal in character, is a development of the past decade. Where formerly such industries existed in only a few of the large industrial centers, they are now widely spread, coming nearer to the places of production of the raw materials. Only by chemical tests can such trouble centers be found.

The character of the water supply, the degree of hardness and the nature of its soluble salts, has only recently been demonstrated to be a very important, if not the controlling element, in the production of obnoxious odors in sewers and around treatment plants.

This information, as determining the need for provision for chemical adjustment of the sewage reaction by the addition of lime, alum, or other chemicals, so as to bring about conditions favorable for the subsequent biological processes of digestion and oxidation, or for provisions for treatment with lime, chlorine, or other means for odor control, is a vital factor in intelligent plant design. Such a chemical study may, further, determine the necessity of having certain wastes treated at their source or kept entirely out of the municipal system.

As has been said, sewage disposal is, primarily, a biological process. It is obviously important then to have previous knowledge of what is to be expected in the biological processes incident to the operation of the plant. Biological peculiarities of raw sewage are often encountered, such as the predominance of some particular organisms that may affect the plant operation. The factor of greatest interest to the engineer, however, is the biological action that takes place after the sewage enters the plant. This action governs several design features, for it determines gas production, odors, foaming, the quality of the digested sludge, size and depths of the sprinkling filters, and the efficiency of the activated sludge operations.

The adjustment of chemical reaction to promote

rapid biological action has been touched upon in the preceding paragraph. An experimental study of the biological processes of digestion and oxidation of the particular sewage to be treated, and of the effect of varying degrees of change in chemical reaction, is necessary if the most efficient and most economical plant is provided. Such a study may, also, be a deciding factor in determining the need of chlorination, and the point of chlorination which may not be the same with different sewages.

A full preliminary study of the various factors discussed above is clearly necessary for the designing engineer, if he can say, with any degree of assurance, that the plant is economically designed, and that it will produce the results required with the lowest possible maintenance cost to the community. The changes, often costly, that are made in many plants shortly after being placed in operation are, in large measure, evidence of insufficient study, by the designing engineer of the particular sewage with which he has to deal.

Passing now to the study of sewage from the standpoint of the operator. It is impossible to stress too strongly the importance of intelligent, conscientious operation of sewage disposal plants. This cannot be secured unless the operator understands not only the operation of the mechanical equipment, but also understands the purpose and function of each unit of the plant in the treatment of the sewage. To do this requires laboratory testing, the extent of which will depend on the type of plant and the quality of effluent desired. Considering first the physical properties of the sewage, the operator should have accurate data on the daily and seasonal flow rates. The increased flow to expect with heavy rains is valuable information. Varying flows affect the period of detention in the grit chambers, settling tanks, and aeration tanks, the rate of flow on the sprinkling filter, and govern the amounts of chlorine or other chemicals required. It is, obviously, more economical to adjust the operation of the units of a plant to the flow, rather than running it constantly for a peak flow. This is particularly important in plants with mechanical equipment where power consumption is a major item in the cost of plant operation.

Data on the settleable solids are an aid to the operator in gauging the operation of the plant units. This is of first importance in plants dealing with canning

and packing house wastes which contain large amounts of solids, that fluctuate daily and seasonally. These wastes seriously affect digestion tanks, often causing foaming and acid digestion. It may be impossible to overcome all of their injurious effects, but an alert operator can do much to reduce them. Where chlorination is practiced, the operator would immediately suspect the need of increased dosage with increase in solids.

The amount of suspended organic matter passing the settling tanks is a gauge of the load to be put on subsequent treatment. The quantity of suspended solids forms the best criterion of the success of plant operation. Tests for the quantity of suspended solids like many others, are of the greatest value to an operator when he has made them over a period of time covering varying conditions. Associating these results with the tests on effluents from subsequent operations, makes it possible to intelligently operate the plant.

Considering the chemical aspect of sewage in its relation to the operator, we again encounter the problem of trade wastes. Ordinary domestic sewage offers practically no difficulties from a chemical standpoint. A few of the more common wastes are those that inhibit bacterial action, those that produce odors on decomposition, and those that cause acid conditions in the digestion units. These wastes affect the operation in various ways. Some of them, such as oil and grease, must be trapped and removed. Acid or caustic wastes must be neutralized. Wastes containing milk, sugars, or high amounts of carbohydrates, will generate large amounts of gas, generally with odors, in the digestion tanks, and have a tendency to become acid. They will also throw a heavy load on the aeration units or sprinkling filters. Other wastes may have still other effects to try the operator.

The peculiar biological qualities of raw sewage that may affect plant operation are rather limited. Occasionally, growths of certain organisms may cause trouble, by clogging screens or by forming large masses in the tanks. In some trade wastes, as, for example, milk, where the sewage flows slowly through a long outfall line, there may be a marked increase in putrefactive organisms, causing odors and acidity.

In plant operation, the biological processes are so closely inter-related with the chemical actions that it

is impossible to definitely separate them. Since all the digestion processes have a biological basis, it is necessary that the operator be able to make and understand such tests as will enable him to tell quickly when conditions are changing.

The development of the use of colorimetric standards for the determination of acidity has been a great aid to sewage plant operators. A close relation to success of operation will be found connected with an intelligent use of this test. The effluent and samples from a settling tank will be slightly more acid than the raw sewage, but if much of an increase is noted it may be due to clogging of the vents in an Imhoff tank, or to failure of the cleaning mechanism in a mechanical clarifier. The hydrogen ion concentration, usually stated as pH, of the sludge in the digestion tank, has become almost the only test for its efficiency. For most tanks it is found that if the pH is kept between 7.0 and 7.6, that the operation is satisfactory, although good results have been noted at both lower and higher figures. The effluent from aeration and sprinkling filter units should have a pH of over 7.0, as that will indicate good oxidation.

In conclusion, it should be realized that, as the present day is one wherein the success of every engineering and industrial undertaking is measured by its efficiency, as determined by the standard of economical production, the design and operation of sewage treatment works must be measured by this standard. The recent developments in the field of biochemistry have supplied the scientific basis for intelligent design and operation. To design a sewage treatment plant without first studying the sewage to be treated is to attack a complex problem blindfolded, with but slight chance of success. To attempt to operate a plant without control by tests conducted by an operator who understands their purposes, is to invite failure. Measured by the standard of efficiency of other industrial enterprises, the public is entitled to sewage treatment plants, well designed, and well operated.

Sludge Digestion

By C. G. Gillespie*

Sludge as freshly deposited is just concentrated sewage. It is usually gray or brown in color, with particles of paper, feces, and debris of various kinds. Carbon and nitrogen compose by far the greater part of its organic elements. When it is concentrated to dryness and then burned 15 to 40% of it will not burn off. This part is called the ash. The remaining 60 to 85% is volatile, and it is that part that digests. After digestion it will be found that the volatile matter has been reduced around 50%. A part of this loss is due to a change of volatile matter to ash, but a substantial percentage is liquefied or gasified and is actually lost. It was the too literal belief in that phenomenon that gave rise to the contention that septic tanks never needed cleaning.

Raw sludge is very watery. Even a few inches below the surface it is apt to contain 95% or more of water. Let it stand a few hours and it will smell offensively. Run it out on a sludge bed and it will be nearly all water. A foot of it will give only an inch or so of dried cake. The dried surface looks 'tight', and water evaporates out of it very slowly.

Digest it properly, and, as most of you know from personal experience, it looks like a coarse, homogeneous, humus-like mud, thick and black, and its odor is tarry or rubbery at most. As it issues from the sludge pipe it will exhibit a rather granular texture. You will see gas bubbles breaking freely; there may even be signs of curdling in it, especially after it has stood for an hour or so. It is decidedly not watery, but flows real stiff. Tests will show 85 to 92% water. A foot of it will dry to say 8 inches. However, the wateriness is not a definite criterion of digestion, except that it should not be real watery. Sludges vary greatly in their power to hold water, just as do soils. In the early days, sludge capacities were figured on the basis of 85% water. This makes sludge chambers half too small, if the sludge develops to be one containing 92.5% water.

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The reason for the variation is that the granulation is variable. Sludges that remain colloidal, like adobe soils, hold much water. Sludges that are granular give up water freely.

On the sludge beds, the crust of digested sludge should be rough and full of cracks, every inch or two apart. Below the crust the appearance will be dark colored and porous like a sponge. There will be no sour or stinking smell. If the sludge cake is dense and pasty, it is a sign of imperfect digestion. There should be no satisfaction to an operator if the sludge let out on the beds is undigested and odorous, even though he may get by with it.

In any sludge tank, we have sludge between these extremes of gray, raw sludge, and dark, digested sludge. Let us trace what the research workers tell us is going on there. Reduced to simple terms, the sludge tank abounds in numerous species and numbers of primitive organisms whose nutritive processes are so complex we just begin to sense them. They live on the things most easily broken down chemically. But one fact stands out, and that is that if you take a batch of sludge and trace through its digestion you will find that at once it becomes acid. This afternoon, E. A. Reinke, my assistant, will tell you how acidity is measured. As I have got to use the term which he will define, I will tell you it is 'hydrogen ion concentration'; it is abbreviated to pH. When the figure is 7.0 the substance is neutral. Above 7.0 it is alkaline, and below 7.0 it is acid. You can readily understand that the further the pH falls below 7.0, the greater is the difficulty of the primitive organisms to stand it.

According to Willem Rudolfs, director of the New Jersey Sewage Experiment Station, and others who have studied sludge digestion scientifically, it passes through three phases to become inoffensive and drainable. For the first two or three weeks the starchy sugars, vegetable pulp, and cellulose being most unstable, are attacked. B. Coli are abundant in this stage. Heavy gasification sets in, and tests will show the gas to be high in carbonic acid and nitrogen. Scum formation appears. The odor is bad. The vent liquor may be clear or a little cloudy. The acidity may become as low as pH 5.1 to 6.8. By the close of this

A Badly Neglected Imhoff Tank. The Crust on the Flowing-Through Chamber Supports a Man's Weight—R. F. Goudey. Another Reason for the Necessity for Better Sewer Maintenance

Sludge Beds at Imhoff Tanks, Stockton, California. An Example of Good Sludge Digestion. F. H. Tibbetts, Designing Engineer

period the responsible organisms have died off and only the more resistant acid-consumers remain.

There then sets in the second period of digestion, which is one of sluggish digestion, during which the nitrogenous matter and the organic acids formed in the first period are gradually consumed. Odors are still bad. Fats are only partly broken down. Scum and the flowing-through chamber look greasy. The vent liquor is turbid and foaming is usually at its height. Little gas is formed, but it contains less carbon dioxide than formerly. Hydrogen gas, which is combustible, begins to appear. The scum is sour looking and inactive. The pH is 5.1 to 6.6 or 6.8. The time consumed by this period depends on the accumulation of acid material. In cold weather it may last the entire winter. Some tanks never emerge from it.

The third period sets in when the rate of acid reduction exceeds that of acid production. The pH will now range from 6.9 to 7.4. The proteins and organic acids and fats are now being mineralized by spore formers and fat-splitting organisms. The solids turn from yellow, brown, or gray to black. Scum is thin or absent. Contrary to popular opinion scum formation is in reality an unhealthy sign. Gasification is active, the bubbles breaking clean. Tests will show the gas to be largely methane. Odors at worst are tarry or rubbery. Liquor is turbid to clear. The animal organisms, protozoa, are finally present. The sludge will now meet all the specifications of digested sludge.

If by chance the pH is allowed to run above 7.6, it has been found that the sludge again becomes exceedingly odorous, and sets into what may be called a fourth stage, in which a new flora springs up, attacking the semi-resistant compounds which would otherwise be classed as digested.

In Imhoff tanks, the signs of faulty digestion are not limited to sludge itself, or to the scum, or to foaming. They show in the flowing-through chamber and in the effluent. The liquor from below is working back and forth through the slot all the time. Whatever is offensive in it returns to the flowing-through chamber; if the vent liquor happens to be greasy, a greasy scum will be seen on the flowing-through chamber; if the liquor is full of odor, that odor will be

evident in the effluent. In a well behaved tank, the sludge liquor, or as I have called it, 'vent liquor', is quite clear and inoffensive, because the first two stages which are offensive are shortened and their ill-effects very much neutralized.

There are several reasons for the ebb and flow of liquor through the slot. Going on all the time, is the natural expulsion of water from the digesting sludge. When the digestion chamber receives daily sludge with say 95% water, dissolves say 20% by weight, and delivers a sludge of say 85% water, it expels about 130 gallons per 1000 population, which water can escape only through the slot. Reinke and Wright, at Livermore, have shown too, by the use of dye that baffle-induced currents penetrate the slot and then emerge. Again, when you hose down the gas tanks, the several hundred gallons of water must rise through the slot. Due to temperature overturn also, cold sewage on top and warm sludge beneath, must result in a circulation within the slot zone. Tanks with narrow overflow weirs experience a rise and fall in water level as the flow varies and this transmits through the slot. So naturally, if the vent liquor is greasy or turbid or smells badly, these things are bound to appear in the flowing-through chamber, as they do.

From what was said of the changes in batch digestion, it is apparent that in the bottom part of the tank there is well digested, highly alkaline sludge. The top sludge is acid. In a tank which is functioning properly, there is a certain balance or mutual adjustment between the digested sludge and that which is digesting. According to Dr. Rudolfs, the ripe sludge on a dry basis should be fifty times the daily admission of raw sludge on a dry basis. To use this information requires scientific maintenance, but I think any operator with the principle before him can accomplish a great deal by a mere trial method. From the tanks I have seen around the State, it is quite evident that the fault of operating with too low a sludge level is altogether too common, and most operators have nothing in their tanks but raw and semi-digested sludge.

A better procedure is to let the sludge level build up as long as improvement in the sludge and general operations is manifest. In tanks that have accumu-

lated a great mass of acid sludge, it may take many months before digested sludge begins to form. In these extreme cases, if there is a chance to by-pass the tank once in a while, it will hasten the recovery. However, the sludge level must not encroach within a couple of feet of the slot, and I surmise that many of you will find that your tanks are too small to meet both rules. Sludge capacities of our tanks have been rather empirically figured in the past. At first the allowance was 0.75 cu.ft. per person. Then with equal empiricism it was raised to about 2.0 cu.ft. What it will be when tanks are designed in the light of each individual sludge, will almost surely be something different.

To obtain the neutralizing benefits of ripe sludge on digesting sludge, a certain amount of agitation is necessary. In the case of an Imhoff tank or any digestion tank, mixing is induced by the rising gases, but I question if this source of agitation is reliable. When you need it most, you may not have it. Tanks equipped with water jets in the bottom give you a better means of breaking up the stratification. I have read recently that in Germany the mere turning over of the sludge by a circulating pump has halved the time of digestion. In more recent devices for sludge digestion in which the sludge is digested separately in tanks equipped with mechanical scrapers, you get a positive, gentle mixing, mechanically.

In establishing a proper balance between raw and digested sludge, you are simply utilizing natural forces. But a palliative or remedial method of neutralizing acidity, heard about a good deal nowadays, is a chemical one, using lime, with the idea of passing the sludge through its acid-forming stage more rapidly. The lime is used either to neutralize the acidity already formed in the tank, in which case it may take hundreds of pounds, or even tons in large plants; or, the better way, is to add the lime as a preventive, applying it daily to the sludge as it is depositing. You may also need an occasional general treatment. It is a waste of lime to add it to the raw sewage.

To correct acidity already established, it is important that enough lime be used at once to bring the reaction up to pH 7.0, or a little better. The lime should be used as a solution and jetted evenly throughout

the liquor, the sludge, and the scum, wherever it is acid. Possibly dry lime can be mixed into the scum. To get at the amount, one easy way is to take a bucket of the liquor, scum, or sludge to be treated, and add lime water until you get the desired pH. The pH should be right after the reaction has had a couple of hours to complete itself. By a little arithmetic you can figure the amount of lime your tank needs. The cheapest lime is the one that will raise the pH the most for the least cost. If in doubt about this, procure samples of various limes from a dealer and add exactly the same amount of each to a row of buckets all containing the same amount of liquor and test each for pH, aiming to create a pH in the working range of 6.8 to 7.6.

I have only touched on the effect of temperature, but you can readily understand that the organisms will work most efficiently if given comfortable, even temperature all the time. Every designer can do much to insulate around tanks by burying them or by embankment; but still greater good comes from artificially heating the sludge. In parts of the East, The Dorr Co., I understand, have done excellent pioneer work in this field. Their separate sludge digestion tanks are provided with gas collection domes, and the gas caught furnishes the fuel for automatically maintaining the correct temperature in coils within the sludge tank.

Good preliminary work has been done by the New Jersey Sewage Experiment Station on the effect on digestion by oil, salt, cellulose, laundry waste, and certain inorganic trade wastes. Oil up to 400 gallons per million gallons of sewage, with all the oil left in contact with the sludge, exerted no detrimental effect; but above this there was a retardation of digestion. As all of you know, however, it would mar plant appearance. One-half of one per cent of salt added to the sludge did not impair digestion. Sulphuric acid in small amounts actually stimulated the first stages of digestion, but larger amounts were retarding. Sulphur black dye was detrimental at all times. Laundry wastes, amounting to 10% by volume in the sludge, had a somewhat deleterious effect. Cellulose and paper were found to settle at the inlet end of the Imhoff tank, and to set up intense rates of digestion

there. It is evident that there is a classification of solids deposited in the Imhoff tank, and this may explain why you find increased foaming troubles toward the inlet end.

That these things are worth while is indicated by

New Activated Sludge Treatment Plant at Dunsmuir, California, on East Bank of Sacramento River. Equipped with Simplex Aerators, and Dorrco Clarifiers and Separate Sludge Digestion. This Plant has Experienced a Peculiar Fungus-Like Growth in the Sewers, Presumably Caused by a Soft Water (Low Acidity) and a Fresh Sewage

the great reduction in digestion time. Engineers figure at least six months digestion where there is no control, and even then often fail to get digestion. With proper temperature and reaction, digestion occurs in 30 to 40 days. Since the flow through the settling chambers can stand considerable overload, then if anyone can find a way to get greater efficiency out of the digestion tank, he will be making good money for his taxpayers.

Reducing or eliminating the odor in the liquor, reduces or eliminates the neighborhood nuisance. And, controlling scum formation saves the operator labor better spent in other forms of operation.

There is one form of scum which operators seem to work over endlessly. It is the woody, indigestible stuff like matches, seeds, etc. When this stuff gathers to a certain point it had better be removed to pits, for it will never digest.

The 'morsel' in this that appeals to me as of immediate tangible importance to operators of digestion tanks of any kind, is Dr. Rudolfs' insistence that di-

gested sludge should be built up to, and maintained in, a definite proportion to incoming sludge. Whether 50:1 is right, I do not know, nor is it necessary to have the figure precise to make progress. I believe one who is observing can go ahead, feeling his way along with safety in building up the sludge level to a proper height. I would expect that the relationship is not fixed but is at least responsive to seasonal changes and variation in sludge production. For instance, in anticipation of sluggish winter digestion, a larger storage of digested sludge should be obtained; the same in a plant about to take on a summer vacation load, or the operations of some cannery or factory operating seasonally.

There are parallels in support of this relationship idea I can draw from other departments of sewage disposal. We all know that when stream dilution is depended on to assimilate an effluent, oxygen, nitrates, etc., in the stream must be adequate to satisfy the appetite of the sewage. The laws of dilution are pretty well known. May not the digested sludge be like the assimilating stream, furnishing not oxygen and nitrates, but other stable end-products which in a way combine with the unstable ones to stabilize them? And may not such a volume of digested sludge also act as a mere physical diluent of an offensive sludge, and of unfavorable acid and other conditions? May not this digested sludge also be the abode of the primitive organisms, and of the energy which causes assimilation of the unstable sludge, and therefore should there not be a definite census of organisms to consume the definite amount of incoming food supply for them? We know mighty well, in the activated sludge process, that each sewage needs a certain portion of returned sludge to carry on the process efficiently. As a more homely comparison, the farmer with a certain amount of swill would have only a certain number of hogs. If he had too few, the pen would be littered with such offensive material, and if he had too many, they would be rather lean.

Reasoning from this, should there not be a larger census in winter because the lethargy lessens the activities and appetites of the individual organism? It is mass appetite that must be maintained.

There are pitfalls to be sure. Dr. Rudolfs points out

one when he says that too prolonged digestion runs the pH up to 8.0 or more, and terrific odors return. One remedy, however, is simple—draw off sludge.

But, at any rate, I feel that we have a new tool in our kit. The acid reaction test and control is the yardstick that goes with it, to measure how that tool works. The acid reaction outfit ought to be the most important part of the equipment of the plant.

It must be apparent from this paper that there is a lot of thought, observation, and work required to run a digestion tank.

Engineering designs can do much to facilitate more rapid digestion, by providing better insulation, making it easy to sample sludge at any level desired, obtaining the advantages of good admixture of top and bottom sludge, and perhaps returning to the water-jet system in the sludge hoppers as one means of adding lime solution.

Engineers can also do a great deal to make operations more convenient and less arduous by making it easy to get rid of trash in the scum vents, frothing scum, and oil in the flowing-through chamber. Plants should have good stairs, not mere ladders, and wide walkways. The overflow weirs should be long so as to avoid the changes in water level which react unfavorably through the slot.

I would say the main needs of our operators are not only a little more work, but a lot more sampling and sounding, and a lot more keeping of notes of measurement, observations, and operating events.

DISCUSSION

Mr. Perry referred to the practice of some operators of burning oil which had come down the sewers by lighting it in the plant, and asked if this was dangerous. Mr. Gillespie replied that it was risky to use lighted matches around a plant and suggested as a topic for a luncheon discussion the causes of the blowing up of various tanks around the State. He added that he did not want to give the impression that oil was desirable in sludge digestion, the reverse being the case, but that it was not as harmful to digestion as some might think. Oil is one of the most troublesome things to operators, but there are hopeful times ahead. Oil burning devices are being perfected to use old crank case oil, and it may have some value, but more

rigid control and inspection is desirable. The cost of inspection is pretty high, but he believes that by just hammering on violation, and advertising the objections to the oil, the public can be awakened to the damages that are being done.

Mr. Knowlton stated that in Los Angeles they were experiencing difficulty in enforcing ordinances governing the use of traps. They have arranged with the health department to inspect the traps, and are hopeful and will continue trying. The present ordinance requires a very small trap, but a new ordinance requiring larger traps is proposed. It is also proposed to require traps at packing houses, which contribute oil, sand, and considerable packing waste to the sewer.

Mr. Burgess described the experience with separate sludge digestion at Gilroy, which has a population of about 5500. The plant was started last November, and no sludge has been withdrawn. The sludge digestion tank is 50 ft. in diameter and 20 ft. deep, with about 7 ft. of sludge in the bottom. During the peach season peach waste, from 4800 tons of fruit packed, got into the plant and made it look more like a garbage plant than one for sewage disposal. By adding lime to the sludge digestion tank, a pH of 7.0 was maintained. More recently tomato wastes, which are quite acid, have been run into the plant and the pH value has dropped a little below 7.0. The average daily flow of sewage is 650,000 gallons, and 10,000 to 12,000 gallons of sludge is pumped daily to the separate sludge digestion tank. The sludge ratio of fresh to old seems to be all right.

In response to a question by Prof. Reynolds as to the number of plants using pH control, it was brought out by Gillespie, Goudey, and Kennedy that at least eight plants are using the test. Mr. Gillespie described the performance of the new separate sludge plant at Roseville, which, with a soft water supply, started out quite acid, but gradually changed to an alkaline condition, at which time scum disappeared and gas broke through clean with no odor. He also reported reading a recent article describing work in Germany with undersized Imhoff tanks which have been made to serve by re-circulating the sludge with a pump, and reports indicate the digestion period was cut in half.

Mr. Kennedy recounted experiences at Dunsmuir paralleling those at Roseville, both having soft water

supplies. He urged that operators keep notes and records of operation of their plants. Individual notes may be of little value, but combined information through the California Sewage Works Association may lead us to intelligent solutions of our problems.

Mr. Schuyler emphasized the importance of the relation of the raw water supply in the question of sewage treatment, and that sewage treatment should begin with an analysis of the raw water and end with a similar analysis of the purified effluent. Mr. Gillespie remarked on the change observed at Santa Maria, where with very hard water, hydrogen sulphide was given off at the Imhoff tank in large quantities, making the surroundings terribly odorous; whereas, after changing to a soft water, the hydrogen sulphide disappeared, and the sewage and sludge became sour and acid.

Prof. Reynolds and Alva Smith remarked that many operators and others who should be at the meeting were missing good information. Prof. Reynolds suggested that a simple statement of apparatus needed, and instruction for its use, be sent to operators, and Mr. Warren answered that Mr. Gillespie of the State Board of Health had given that consideration.

REMOVAL OF OIL AND GREASE

Increasing attention is being given to the removal of oil and grease which make more and dirtier work about the plants. At Essen-Rellinghausen and Kettwig a large proportion is brought to the surface by air blown in with the sewage, drawn off to a separate basin and then skimmed off. At Essen-Rellinghausen the material separated by a 3-minute detention in the grease catcher contained 34.8% of dry matter, of which 5.75% was ash and 60% fats. At Kettwig, where 55 of the 70 gal. per capita per day is from wool scouring and textile works, from 40% to 60% of the fats are removed.—(W. Rudolfs — Public Works, July-Aug., 1928.)

Odor Control by Chlorination

By R. F. Goudey*

Considerable experimental work has been done in California—at Whittier, Davis, Porterville, Tulare, Wasco, and the Orange County cities—trying to cope with odor nuisance by chlorination. The work at Whittier, Davis, and Porterville proved promising, but was not carried beyond the preliminary stages.

At Wasco, E. A. Reinke, of our Bureau, found that creamery wastes, when chlorinated and disposed of by broad irrigation, would not become odorous, if within 18 or 20 hours the wastes seeped away into the ground. The total cost of the chlorination was only 0.02 cents per gallon of milk received. This, in short, was a remarkable discovery, and was corroborated by similar work done on even a larger scale at Tulare. Wasco was the first community to actually adopt chlorination of creamery wastes as a method of overcoming a gross odor nuisance. The city of Newport Beach is the first and only city in California, now regularly employing chlorination for odor control of its Imhoff tank, situated alongside a highway.

There is particular need of odor control at treatment plants and on outfall sewers in California, because of the following considerations:

(1) Isolation is decreasing, and neighbors are generally resentful of the odors and even of the works themselves.

(2) Outfall sewers are relatively long, and they age the sewage.

(3) Most of the water supplies are low, or lacking in dissolved oxygen, and have high mineral sulphate content, tending to accelerate breakdown of mineral sulphates to hydrogen sulphide gas in the presence of organic matter, such as sewage.

(4) The sewage is relatively concentrated, high in oxygen demand, and rarely diluted with infiltration or runoff.

(5) Temperatures which prevail throughout the

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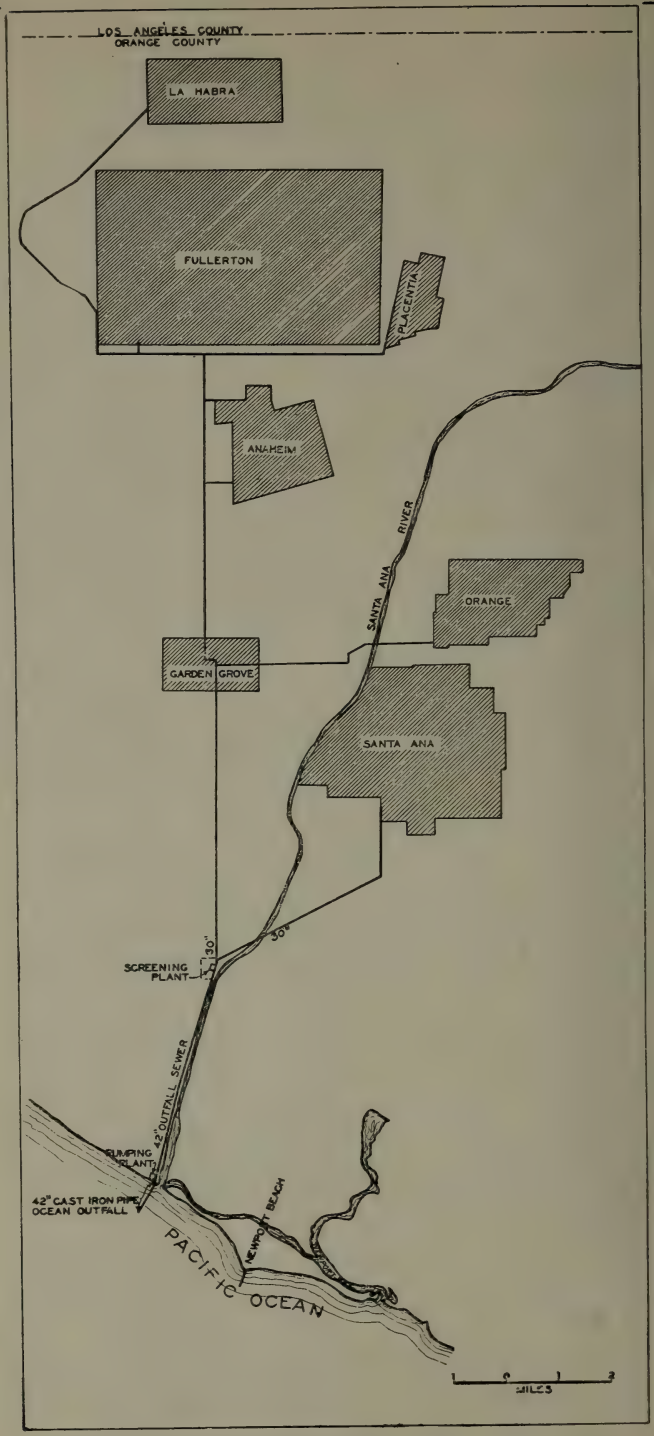


Map of Orange County Cities Joint Outfall Sewer District

summer period are high, and therefore sewage decomposition is probably more rapid than elsewhere.

Particularly bad odor conditions have existed along the old Los Angeles City outfall sewer, the Orange County outfall sewer, and the El Centro outfall, all of which have caused odor nuisances covering literally many square miles of territory. Odor control along outfall sewers and at treatment plants is a common requisite of our sewage disposal.

Odor control on outfall sewers, as distinguished from odor control at treatment plants, is a rather new development. One of the first articles dealing with odor control on outfall sewers appeared in the 'Engineering News-Record', Vol. 98, page 16, in connection with work done by this Bureau on the El Centro outfall sewer. Resort was made to such expedients as using bluestone, running the sewers full, closing vents, and other methods to control odors, but these methods were either too costly or were impractical, leaving no reasonable solution at that time.

Two years ago, L. H. Enslow of the Chlorine Institute, learned of the work being attempted at El Centro, and offered to assist in experimenting with chlorine gas as an odor retardant in sewage. Owing to the remoteness of our office from El Centro, it was decided to try out Mr. Enslow's suggestions on the Orange County outfall sewer system. There was imperative need of work being done on the Orange County outfall, inasmuch as complaints, signed by hundreds of persons alleging odors from the outfall sewer manholes and vents had been received.

The Bureau, in cooperation with Mr. Enslow, and with the Wallace & Tiernan Co., which provided chlorinators and assisted in collection of samples, and further with assistance from the Orange County Health Department in analyzing samples and assisting in the collection of other samples, carried on this experimental and demonstration work on several occasions over a period of two years, and at times had as many as four men in the field. The total cost of this demonstration, exclusive of Bureau time and expense, was over $5000; the object being primarily, not only to experiment but to demonstrate on a large and practical scale, the influence of the chlorine. The last series of tests included over 500 determinations. Thus

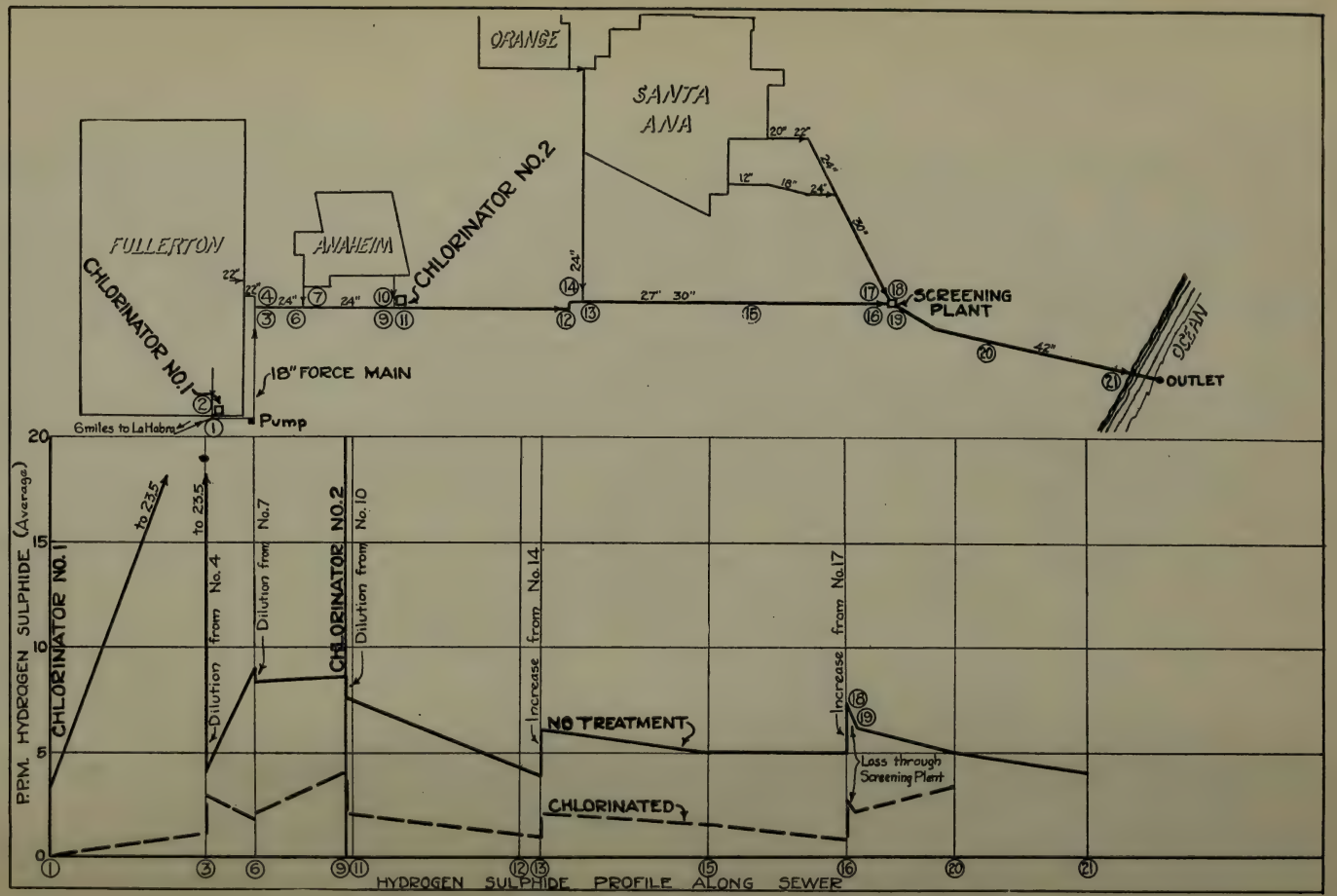


Diagram No. 1. Reduction of Hydrogen Sulphide by Chlorination, Orange County Cities Joint Outfall Sewer

no small amount of data has led to the conclusions reached, which I prefer to regard as tentative.

Description of Orange County Outfall Sewer System—The Orange County cities, consisting of Fullerton, Anaheim, Orange, and Santa Ana, totaling a population of about 70,000, are linked together by an outfall sewer system, varying in size from 18 to 42 in. diameter; the length of trunk sewer being about 26 miles. All gravity sewers are laid on good grades, giving minimum velocities of three feet or more per second. Diagram No. 1 gives a general plan of the outfall sewer system. At the upper end the flow is only 300,000 gal. per day, and at the lower end 5,000,000 gal. per day. Rarely does any part of the sewer system flow more than one-half depth. Seven miles below the upper end of the sewer system the sewage from La Habra and West Fullerton is pumped through an 18-in. main, two miles in length, to join the gravity sewer serving the city of Fullerton. The detention of the sewage in this force main varies from 10 to 20 hours, averaging 12 hours.

A chlorinator, No. 1, was installed at the head of the La Habra-West Fullerton pumping plant, for the purpose of studying the influence of chlorine where there was long detention as in the force main. In addition, it showed the pronounced effect such chlorination had on the entire outfall sewer system below.

The second chlorinator was installed just below the Anaheim sewer, which is approximately 2½ miles below the junction of the force main just mentioned, and the Fullerton sewer. This was not an ideal place in which to chlorinate sewage because of the high initial hydrogen sulphide content, and was selected only because it was a convenient place at which a chlorinator could be erected. The effect of such chlorination, however, was good, and throws light on what could be done if the chlorinator were installed farther up the line.

Only these two chlorinators were used in the work; no chlorinators being used on the Orange and Santa Ana branches. Even at that chlorination counteracted the effects of the Orange City sewage in the outfall. The sewer system, however, is laid out in such a way that if Santa Ana and Orange sewers were each chlorinated, and the Anaheim chlorinator moved up to Fullerton, and judging by the effects of the two which

were actually used, then odors in the entire system would be amply controlled.

The upper chlorinator, No. 1, gave best results at a dose of 50 lb. per day, which is equivalent to 150 lb. per million gallons. At times, residual chlorine was noted at the end of the two-mile force main. Chlorinator No. 2 was operated at 150 lb. a day, giving a dose of about 80 lb. per million gallons.

The time of travel of sewage from Fullerton to the ocean is nine hours, and from La Habra to the ocean 21 hours. The time of travel from Chlorinator No. 2 to the screening plant, or Station No. 16, is 5 hours.

Phenomena of Odor Production—Attention is first called to Diagram 2, which with one exception, shows hydrogen sulphide curves, with no chlorination. These curves give the hourly variations of hydrogen sulphide content in the Fullerton sewage, and the Fullerton-Anaheim and Orange sewage, at Station 16. Both curves represent the extremes of the system, indicate similar characteristics, and prove that the hydrogen sulphide production is related to sewage flow.

I interpret these analytical results to indicate clearly that when the sewage nears the average flow, mineral sulphates are attacked, producing various sulphites including hydrogen sulphide. The sulphate splitting organisms apparently start their breaking-down action in the absence of dissolved oxygen, and when the sewage is but two to three hours old. The hydrogen sulphide increases rapidly as the sewage reaches its maximum flow. It is noted that it attains its peak soon after the sewage flow passes its peak. It then falls off rapidly as the sewage flow declines. At minimum flow, there is dissolved oxygen present practically the entire length of the outfall, and no hydrogen sulphide is present. The hydrogen sulphide seems to form initially at a very high rate, in fact, faster than it can be released; but as the sewage flows down the outfall, the rate of release is greater than the rate of production. At the lower end the hydrogen sulphide remains fairly constant for the same sewage flow.

Mineral sulphates show a breaking down in the upper portions of the sewers, and, as expected, return to almost the initial content in the lower reaches, indicating that some of the broken-down sulphates have returned through the oxidizing cycle, probably above

the water line, again producing acid sulphates, and being re-dissolved in the sewage.

The only tests which we were able to employ regularly were for hydrogen sulphide and mineral sulphates. Dissolved oxygen, hydrogen ion, and temperatures were taken occasionally. Unfortunately, neither the hydrogen sulphide nor the mineral sul-

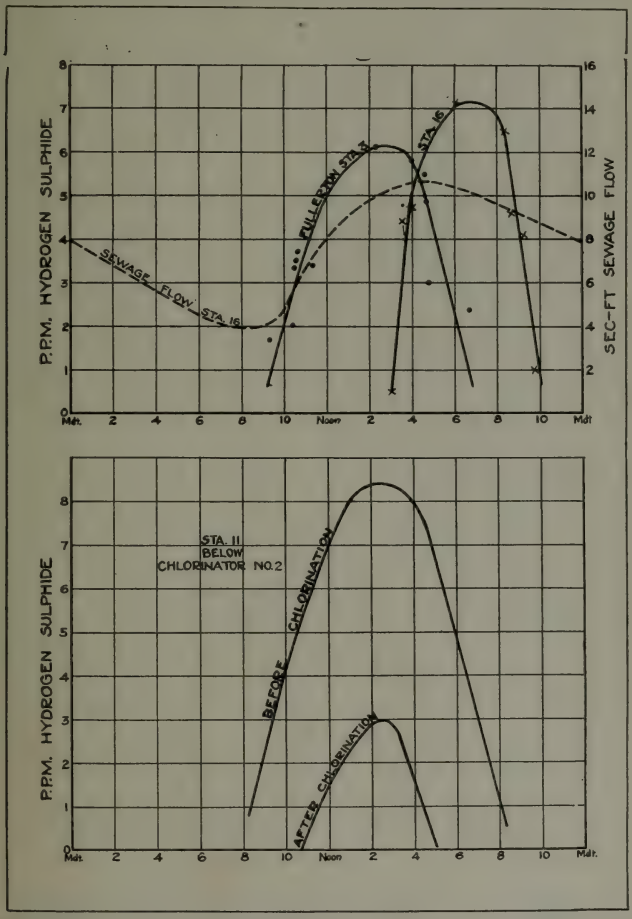

P.P.M. HYDROGEN SULPHIDE
SEC-FT SEWAGE FLOW
SEWAGE FLOW STA. 16
FULLERTON STA. X
STA. 16
Mdt. 2 4 6 8 10 Noon 2 4 6 8 10 Mdt
STA. 11 BELOW CHLORINATOR NO. 2
BEFORE CHLORINATION
AFTER CHLORINATION

Diagram No. 2. Hourly Distribution of Hydrogen Sulphide, Orange County Cities Joint Outfall Sewer

phate tests can be accurately made, and even if they were, these two tests are not sufficient to study the complete sulphur cycle. Various methods for hydrogen sulphide determinations were used, but this past year's work was done employing the Enslow method. This method gave consistent results, and was checked in the field repeatedly by four independent technicians.

It gives the volatile sulphides which no other method does. Great care, however, was taken in not overstepping the end point, and in always making the titration from colorless to blue.

On one survey mineral sulphates were determined by the turbidimeter method, after filtering samples. On others, composite samples were collected and analyzed in the laboratory, determining total sulphur after adding bromine to the composite sample; and the other, using hydrochloric acid to drive off sulphides, giving sulphur in every form but sulphides. The difference gives the total sulphides, but is not a measure of hydrogen sulphide. There is need of a good technique to determine in the field the exact status of the sulphur changes from sulphate to sulphide and back again, and where and when such compounds are combined with calcium, sodium, hydrogen, etc.

It has already been noted that the hydrogen sulphide content appears to be a function of the sewage flow, increasing rapidly when the sewage reaches an average flow, and reaching its maximum shortly after the maximum sewage flow. This is indicated clearly on Diagram 2, and holds for all stations the entire length of the outfall. Because of the uncertainty of analyzing for hydrogen sulphide in amounts lower than 1 p.p.m., and because the hydrogen sulphide production appears to be more closely related to the portion of the time the sewage flow is at or above the average flow, hourly curves were made of all stations regardless of the days the samples were collected, and average maximum and minimum values were taken over the highest 7-hour period. In Diagram No. 1, all the points are averages for the 7-hour high range. A summary of the hydrogen sulphide tests is given in Diagram No. 1.

As expected, the two-mile force main where the velocities averaged about 0.15 ft. per sec., produces the most hydrogen sulphide, averaging 24 p.pm., or about 2 p.p.m. per hour.

The hydrogen sulphide in the Fullerton sewage averaged 4.5 p.p.m., bringing down the mixture to about 4 p.p.m. The adding of old septic sewage from the force main to the relatively large volume of sewage (three times greater) in the Fullerton outfall, caused a very sharp increase in the rate of production

of hydrogen sulphide, so much so, that the rate of increase in the hydrogen sulphide production was greater than the rate of release. In fact, in a distance of 0.9 mile the hydrogen sulphide increased from 4 to 9 p.p.m.

The next connection below the junction of the Fullerton line with the force main is at North Anaheim, 0.9 mile below. Here there is a slight dilution, and the hydrogen sulphide remains fairly constant for the next 1.6 miles. Anaheim sewage dilutes the sewage from above, giving an average hydrogen sulphide content of 7.5 p.p.m. There are no connections from this point for the next 3.6 miles, which for 3.5 miles has no break in alignment, and but very minor changes in grade. However, in this length there is a marked decrease in hydrogen sulphide production. The rate of release exceeded the rate of production, and at the end of this length of sewer the average hydrogen sulphide in the sewage was reduced from 7.5 to 3.7 p.p.m.

At this point a long outfall sewer enters from Orange and it contains a much higher hydrogen sulphide content, causing an increase up to 6 p.p.m. For the next 5.7 miles, there are no new connections, and the rate of hydrogen sulphide production is again equal or nearly the same as the rate of release. At the end of this section is the screening plant and connection from the Santa Ana outfall. The Santa Ana outfall increases the hydrogen sulphide up to 7.2 p.p.m. About 1 p.p.m. is lost through the screening plant, and the hydrogen sulphide content still continues to decrease on the way to the ocean, 4.4 miles distant.

This study indicates that the hydrogen sulphide production is rather sudden in its onset, and gradually diminishes. Additions of fresh or stale sewage to septic sewage, quickly increases the hydrogen sulphide. Sewage, 9 or 10 hours old, seems to have spent its power of producing hydrogen sulphide faster than it can be released.

Influence of Chlorination—Chlorinating the sewage, as above suggested, brought out some very remarkable findings. The No. 1 chlorinator was successful in reducing the hydrogen sulphide from an average of 24 p.p.m. down to about 1 p.p.m., and toward the end of the experiments the hydrogen sulphide at the end of the force main was invariably absent. This is a

very significant finding. If it were attempted to neutralize the hydrogen sulphide at the end of the force main, it would require approximately 75 p.p.m. of chlorine, which is equivalent to about 220 lb. of chlorine per day. By destroying the sulphate splitting organisms before hydrogen sulphide is produced in large quantities and continuing to inhibit their growth, using a dose of only 50 lb. per day, as was done with the chlorinator placed where the hydrogen sulphide was only 3 p.p.m., it did the same work as if 200 lb. per day had been added at the end of the force main. This clearly shows the need of giving proper study to the location of chlorinators on such work.

The mixing of the relatively small volume of chlorinated sewage from the force main with Fullerton sewage, had the effect of diluting the Fullerton sewage somewhat, but, what is far more important, actually brought about a decrease in the hydrogen sulphide in the mixture where formerly, without chlorination, there had been a very marked increase. This can only be explained by the action of end products of chlorination, such as chloramines and chloroproteins, the presence of which was noticed in the manholes by a light, smoky gas, hanging low, and having the characteristic pungent odor of such compounds. Note that at Station 6 the effect of chlorination on 300,000 gal. per day, mixed with 1 m.g.d. of Fullerton sewage, showed a reduction of 9 to 1.7 p.p.m.

The effect, however, of adding sewage from North Anaheim which, by the way, contains packing house waste, gave constituents which the end products were no longer able to grapple with, and there was an increase in the rate of hydrogen sulphide production. Dilution by Anaheim sewage brought down the hydrogen sulphide to 3.5 p.p.m. Here it should be noticed that the mere adding of 50 lb. of chlorine per day on a branch line had the effect of reducing the hydrogen sulphide content in 2,000,000 gallons of sewage from 7.5 to 3.5 p.p.m., using a dose of only 50 lb. per 2,000,000 gallons a day. This can only be explained again by the action of end products, for to have obtained 4 p.p.m. reduction of hydrogen sulphide by chlorine gas directly, with the hydrogen sulphide at 7.5 p.p.m. initially, would have required the use of 160 lb. of chlorine, whereas only 50 lb. did the work when applied at the upper end.

The second chlorinator reduced the hydrogen sulphide from 3.5 to 2 p.p.m., giving a reduction of 1.5 p.p.m. Theoretically, there should have been a reduction of 4 p.p.m. Why there is this difference needs further study. One of the factors was the high chlorine demand due to packing house wastes from No. 7. However, this chlorination caused a continuing de-

Emergency Chlorinator Installed by G. T. Luippold of Wallace & Tiernan, Inc., on Sewage Treatment Plant at Santa Paula, California, Following St. Francis Dam Failure—Similar to Installations on Orange County Cities Joint Outfall

crease in the hydrogen sulphide in the sewage for 9.3 miles in spite of a heavy increase in hydrogen sulphide content from the Orange sewer, which entered 3.6 miles below. Below the second chlorinator the hydrogen sulphide was brought down to less than 1 p.p.m. above the Orange connection, and the effect of end products in spite of the high hydrogen-sulphide content in the Orange sewer kept the mixture down to 2 p.p.m. The hydrogen sulphide content thereafter markedly decreased to less than 1 p.p.m. at the screening plant. The effect of both chlorinators was to reduce the hydrogen sulphide from 5 p.p.m. to less than 1 p.p.m. for the combined sewage of Fullerton, Anaheim, Orange, and La Habra. The end products of this combined sewage had a material effect in reducing the hydrogen sulphide in the mixture over what theoretically should have obtained from the addition of the Santa Ana sewage. There likewise was less hydrogen sulphide removed by the screening plant; but below the screening plan there was a marked increase in hydrogen sulphide production where, without chlorination, there had been a normal decrease. By keeping the hydrogen sulphide content down to 1 p.p.m. and

below, odors were noticeably controlled at the pumping plant, the screening plant, and along the outfall. At the pumping plant odors were so bad before chlorination that forced ventilators had to be operated several hours before operators could safely enter the pump pit. With the chlorinator in operation there was no smell whatever.

At the screening plant odors were particularly bad, but with chlorination there were no odors at the plant to cause nuisance. In fact, the junction manhole of the Santa Ana sewer with the main outfall at night time showed the presence of white gases of the characteristic odor of chloramines and chloroproteins, which were probably responsible for controlling odors at the screening plant. Likewise, all along the outfall, residents opposite manholes each evening would plug up the holes in the manhole covers with corks or papers, and even throw several inches of dirt over the top to prevent odors escaping. This was done on every day in which the manholes had been elevated for collection of samples when the chlorinators were not in operation. One manhole below the junction of the Orange outfall, which was particularly complained of by residents in Garden Grove, was deliberately left open when chlorination was being practiced, and no odors were complained of. In fact, pretty close tab was kept by an operator of a gas station near this manhole, and his comments as to when there were no odors always coincided with the times when the doses of chlorine as above stated were used.

Mineral Sulphates—A number of mineral sulphate determinations were made by the turbidimeter method, and ten samples for chemical determinations were made. The study of the sulphate phase of the work has not yet been completed; hence supporting data for the following statements cannot be made available now. The mineral sulphates of the water supplies vary materially, from 80 to 100 p.p.m. The mineral sulphate break-down has its greatest rate in the upper end of the sewer, and continues to the point where it is overbalanced by an opposite reaction, which at the lower end shows an increase back to mineral sulphates. These results have been carefully studied, and indicate that there is a loss of hydrogen sulphide much greater than can be accounted for by the hydrogen sulphide tests alone. This is what would be expected, and con-

stitutes a check on the entire work. It is interesting to note, further, that chlorination practically stops the sulphate splitting action, and, in addition to controlling odors, prevents acid formation with its consequent destructive action on construction materials containing lime. By chlorinating at a cost of $3000 a year, the outfall sewer investment of nearly $1,000,000 can be saved.

Conclusions—Speaking of this investigation, chlorination for odor control, and less for acid formation, need not be continuous. From Diagram 2, it is evident chlorination need not here be practiced except during about a 9-hour period. The tests further indicate that it takes about three days after chlorination ceases before the action re-establishes itself. Accordingly, if chlorination is practiced six days out of seven, good results should be obtained. Likewise, there may be no need for chlorinating on cold days, or when the sewer is surcharged with rainfall runoff.

If the Fullerton sewage were chlorinated, even as poorly as that obtained at Chlorinator No. 2, it is reasonable to suppose that from Stations 1 to 13 the hydrogen sulphide could be kept below 1 p.p.m. Even with the chlorinators as installed during the experiment, the hydrogen sulphide content was kept below 1.5 p.p.m. during the evening hours when odors are most noticed. It seems remarkable that the two chlorinators as installed, with no treatment whatever of Orange sewage, gave a reduction of hydrogen sulphide at Station No. 16 from 5 down to 0.75 p.p.m., especially since this point is 9.3 miles below No. 2 chlorinator and 14.5 miles below No. 1 chlorinator.

The entire line probably could be most effectively controlled by one chlorinator at the pumping plant, operating continuously, and separate chlorinators at Fullerton, Orange, and Santa Ana city limits. The total chlorine consumption would then be 150 lb. per day.

It is interesting to note that the hydrogen sulphide production occurs entirely during the period as the flow in the sewer reaches an average depth and proceeds to the maximum depth, and for this reason chlorination need only be practiced here for 9 hours a day.

Chlorination of sewage at a point where the hydrogen sulphide was 3 p.p.m., or less, effectively prevented hydrogen sulphide production from splitting

of mineral sulphates, and not only retarded such action for 20 hours, if not mixed with other sewage, but even if mixed with three times its volume, still further retarded hydrogen sulphide production for 7 hours, probably through the action of end products.

DISCUSSION

In reply to a question by Mr. Schuyler, Mr. Goudey gave the cost for chlorine on the Orange County outfall as $1.75 per million gallons, and stated that where sewage is to be treated the effect of pre-chlorination can only be inferred from the results at hand, which indicate a decrease in oxygen demand. He added that it would also reduce the area of pollution around ocean outfalls. At Bath, England, pre-chlorination has controlled odors at a plant 20 miles below the point of application. Mr. Kennedy remarked that at Schnectady experiments indicated that pre-chlorination did not materially affect oxidation of sprinkling filters.

Mr. Rawn asked if any particular data had been obtained on controlling deterioration of concrete by chlorine, and asked if soluble chloride would not injure the sewer. Mr. Goudey replied that if free chlorine had any bad effect it would only be over a distance of 400 to 500 ft., as it would all be used up in that distance. He attributed disintegration in part to splitting of mineral sulphates by bacterial action, and concluded that if chlorination prevents this breaking down of mineral sulphates there can be no disintegration from that source, as the 'mineral sulphate cycle' is stopped at its source. In his experience disintegration occurs where sulphides are above 3 p.p.m., and it may be that by keeping below that value it can be stopped. However, by chlorination, hydrogen sulphide can be kept below 0.5 p.p.m.

In reply to a question by Mr. Reinke, Mr. Goudey gave the experience along the Orange County outfall sewer when industrial wastes with 1600-p.p.m. sulphates was discharged into it. Hydrogen sulphide was at least two or three times as great as at present, and disintegration took place rapidly for a year and a half, due almost entirely to the industrial wastes which were finally eliminated from the sewer. Mr. Warren inquired what the effect would have been on these experiments if the discharge of the industrial wastes into the sewer had continued. Mr. Goudey replied

that it was hard to tell and far safer to keep them out. Mr. Warren stated that was the proper idea, but we should encourage industrial growth. Mr. Goudey answered that in this case, although the company spent

Placing 48-in. Concrete Pipe, with Clay Liners Above Invert, in Tunnel. Men Are Tamping Backfill and Sealing Joint. Los Angeles County Sanitation Districts

$125,000 for equipment to produce acetic acid, potassium sulphate, and ammonium chloride from the wastes, they made money on these by-products.

Chester Smith stated that with industrial wastes it was simply a case of experimenting to find out what dose of chlorine was necessary to hold back sulphate splitting organisms. Mr. Warren brought out the necessity of determining the chlorine demand, emphasizing that in some cases as at Hyperion (lower end of Los Angeles City outfall sewer), the cost might be prohibitive. Mr. Goudey suggested that control should be near the head of the sewer line rather than at the lower end of outfall.

Trials and Tribulations of a Sewage Works Operator

By A. W. Wyman*

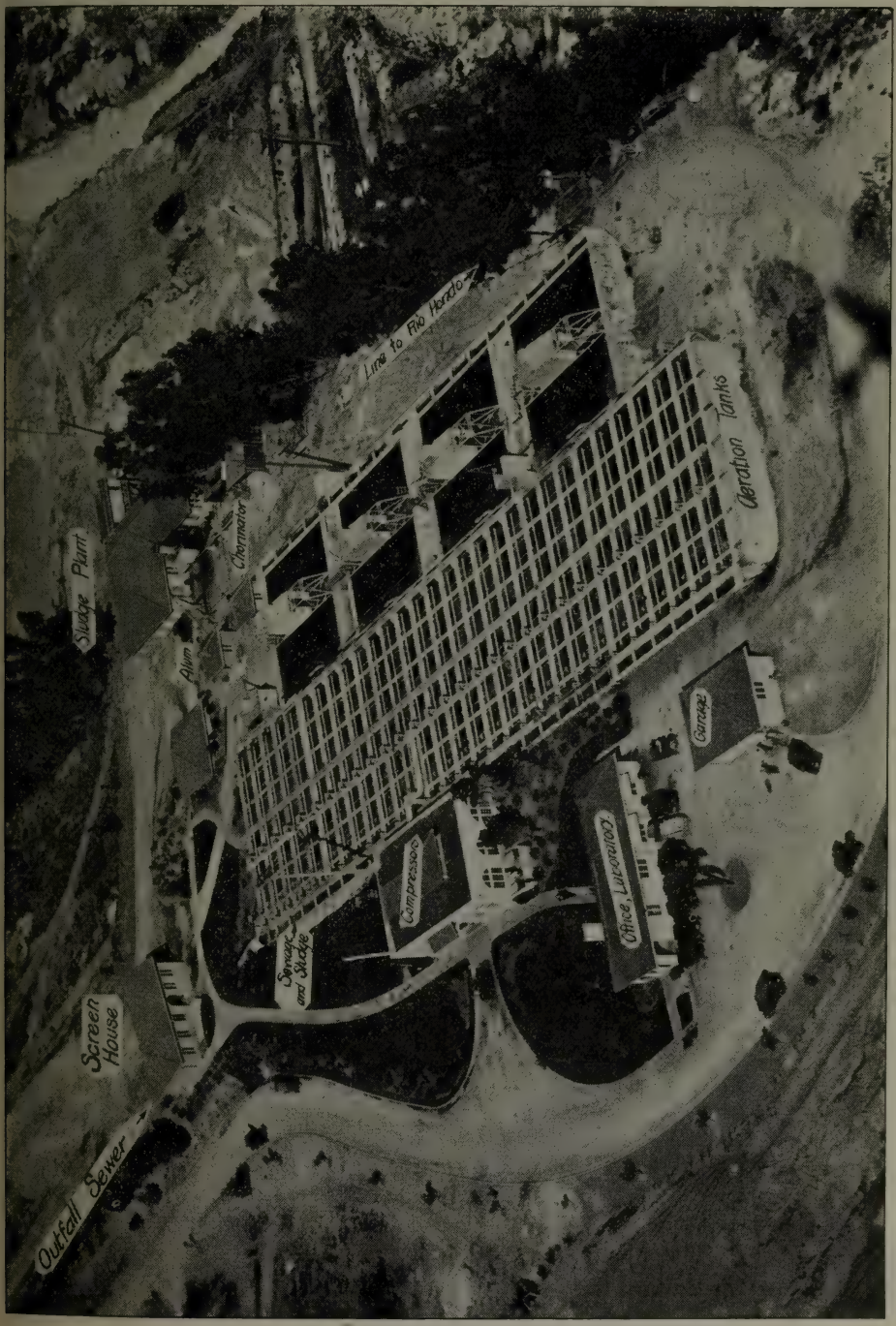
The subject of this paper takes us back to many unpleasant experiences, and except for the many benefits others as well as we ourselves derive from them, we wouldn't care for any post mortems. Trials and tribulations are caused by failures, some impossible to forecast and others by poor judgment, or lack of experience.

At the time Pasadena's plant was started in January, 1924, the activated sludge process in this country was not very far advanced, so naturally many errors were made, some pretty expensive and others merely operators' problems.

The first serious one, and one which is so often made, even by capable engineers, was lack of capacity. This started a prejudice against the plant which has not been entirely overcome as regards our near neighbors. Many figure that if the average daily flow is provided for, enough energy can be stored during low flows to take care of the peaks. This in my experience is entirely wrong, especially when our peak flow (nearly double our average flow) lasts longer than the four-hour detention period which we have found necessary for good results. This lack of capacity included aeration units, clarifiers, effluent return pumps, and sludge filters. It had been decided to discharge the effluent into a wash just below the plant, but at the last minute, an order from the State made this impossible. The reason for this was, that during the two weeks' period after starting a plant, the effluent is very little better than raw sewage, and the stability of effluent at all times must come up to state and county requirements. Besides, the wash, for the most part, ran through private property.

Here was the operators' problem: how to return to the farm property all the effluent, with a pump capacity of about half that amount. The only alternative was to control the raw sewage flow into the plant and bypass the surplus into lagoons or basins. Many thousands of dollars were spent in building basins for this

*Superintendent, Pasadena Sewage Treatment Plant.



ACTIVATED-SLUDGE SEWAGE TREATMENT PLANT AT PASADENA, CALIFORNIA

purpose, and it was in the lagooning that the plant got its bad name. New aeration and clarifier units were rushed to completion, and finally an effluent line from the plant to the Rio Honda was built, which removed the necessity of lagooning the raw sewage.

In the meantime the sludge problem was causing more concern than the raw sewage had. High pressure salesmanship, and a wonderful article appearing in a well known engineering magazine, contributed by the salesman himself, had sold the city a filtering machine used in the paper industry. This machine was housed in a very fine building arranged for its accommodation only, and which later required much serious study to rearrange for filters that are filters.

Going back to the paper machine, a company engineer was supplied with the equipment to prove their guarantee, that of filtering all excess sludge produced by the plant using SO_2 gas as a coagulant. After one or two months' experimenting, this machine was declared worthless, and only by starting suit did Pasadena receive the money paid for it. While all this was going on, sludge was being pumped to lagoons, used for irrigating the orange orchards, and in fact everything which could be thought of to dispose of it. The trials and tribulations during this period are still fresh in my mind. A real nuisance and probably a menace to public health existed. Flies and mosquitos were breeding by the thousands, and irate neighbors, and State Board of Health and County officials, were insisting upon quick action, our neighbors even going so far as to threaten to blow up the plant. City officials were back of every move to improve the situation, in fact, have always been more than liberal in meeting the requirements of the plant. Trenching was finally resorted to, and hundreds of ditches were necessary to hold the half liquid sludge which had been accumulating between the failure of the paper machine and the installation of two large vacuum filters. These filters needed many months to bring them to the efficient stage which they now hold. One instance about these first filters I well remember. Cotton cloths costing about $50 each were lasting only 30 or 40 days, while it was understood that Chicago had a filter whose cloth had been on for six months. Dr. F. W. Mohlman was asked to come to Pasadena to show us where we were falling down. After a very

short study of our records, Dr. Mohlman made the remark that the life of a filter cloth was not in days or months, but was in the amount of material passed through it. The filter cloth at Chicago had filtered 500,000 gallons in six months, the one in Pasadena had filtered 4,500,000 gallons in thirty days of continuous service; so we were not so bad after all. We are now using woolen cloths at $75 each, which last six months and filter 30,000,000 gallons each.

Another serious and costly error was the manner in which filtrous plates were set. Asphaltum was the material used, and many leaks were present when the plates were covered with a few inches of water to test them out. Once the plates were wet it was next to impossible to make asphaltum stick and stop the leaks. These leaks increased in number until nearly all the air was coming up around the plates, and air distribution, which is very important, was impossible. This left nothing to do but remove the plates, one tank at a time, and chip off the concrete edges of the holders where the tar still prevented a bond for the new setting in concrete. Each plate was washed in carbon bisulphide, coal oil, and water before it could be used again, and instead of having new plates of uniform porosity, they were now only about 75 per cent efficient. This was some job in itself, there being about 3000 plates. These plates are still in service, but will be replaced from time to time, which it is hoped will allow a control by which we may show quite a reduction over the amount of air now used.

The blowers caused their share of trouble also, but not as serious. Check valves of the swing type were responsible for a general scramble for the power house to close a positive gate valve, and save some blower from tearing itself to pieces in reverse gear on account of air rushing back through a stuck check. These have been replaced by cushion plunger type checks, needing almost no attention. A gravity oiling system relieves the operator from the tiresome and almost continuous necessity of hand oiling.

The screen house gives very little trouble since the bucket conveyors have been changed from a two chain drive to a single chain. The Dorrco screens are very efficient, and The Dorr Co. may well be proud of this equipment. I am sorry I cannot say the same about their clarifiers, that is, the type which was furnished

the Pasadena plant. These were of the extension arm type which operated from weights and wire cables. These wire cables were replaced many times until cable chain and chain sheaves were finally furnished. These worked. Knowing this equipment was really made for handling mining slimes, I am going to tell you the reason given to me for failure of these wire cables: "Too much sand and grit in Pasadena sewage". It sounded like a joke, but it wasn't to the operator. With 6,000,000 gallons of sewage to clarify and one clarifier out of commission, no wonder we didn't care to see state and county health inspectors. But all that is changed, the extension arms have been discarded and all clarifier tanks (now five in number), have been changed from square to round bottoms, making it possible to try out spiral equipment also, which has been very satisfactory. Nearly all these troubles are ancient history, licked and almost forgotten, but there are still one or two quite recent ones which you may be interested in hearing about.

Burying sludge was using up all surplus waste land, and, besides being a very expensive disposal, began to cut into valuable farm land. Sun drying was out of the question in the present location, so a sludge dryer was installed, and tested out February, 1927. The dryer was a direct indirect type, 70 in. diam. and 42 ft. long, with a dutch oven using fuel oil under 70 lb. pressure. An exhaust fan of 8000 c.f.m. gave the force draught necessary and carried the gases and steam away through a coke filter. The guarantee of this dryer was that it would dry 500 lb. per hour of feed sludge, having a moisture of 83% moisture, and no odor would result from said drying. But 300 lb. was the very best the dryer would turn out, and as to odors, there were plenty. The coke filter, heavy water sprays, and finally chlorine as high as 150 lb. per day, gave no relief. In addition to these, we tried sending it back up the incoming sewer line, but it came out of manholes and the odor was still as bad. Then it was turned down the effluent line, with no outlet until it reached the Rio Honda, four miles away. This gave promise of some relief, but was soon reported to county and health authorities as causing death and destruction to people living half a mile away from the discharge. An ozone generator of 12 grams capacity had been given credit for a slight improvement, so

another ozone machine of double the capacity was purchased on a guarantee that all odors would be eliminated or no money. Both machines are still in storage, and the second has not been paid for. A compromise was made on the dryer, it delivering about three tons per 24 hours instead of six as guaranteed. This left a real problem for the operator. Dryer capacity less than half that which was required by the plant, and still the odors to eliminate. Many changes were made in the dryer. It was lengthened to 60 ft., a new circular fire box built, also a screen and return conveyor for oversize material. This stepped up the output to 4½ tons, still not enough. Experiments with a filter aid, almost immediately brought the results we desired. Filter capacity was increased nearly 50 per cent, and a reduction in sludge cake moisture of over 5 per cent. The effect on the dryer was very pronounced, jumping to 8 or 10 tons daily. This was very gratifying as far as the dryer was concerned, but the odors were still causing many protests; and finally an order came to close down the dryer until some means could be worked out to eliminate them entirely.

Summing up everything that had been tried without success—condensers, water-washers, sprays, deodorizers, chlorine and ozone—we next tried superheating the steam and passing it through a separate fire-box. This fire-box is about 6 ft. wide and 20 ft. long, having an outside shell which the gases and and steam pass through before going into the combustion chamber itself. There are over and under baffles which insure contact for all gases, and a 20-ft. stack discharges them into the outside atmosphere. This arrangement seems to be exactly what was needed for the elimination of these odors, and I believe is the solution for the most persistent of all our problems.

This paper possibly has left an impression that everything must have gone wrong at the Pasadena plant, but such is not the case, for many installations have worked to perfection from the start. Looking back over the last five years, the satisfaction of permanently solving these many problems makes the trials and tribulations of the sewage plant operator not so serious, after all.

DISCUSSION

The paper elicited much applause, especially for the frank way in which Mr. Wyman told of his periods of discouragement and the admirable persistence with which he overcame each obstacle.

Mr. Warren, like many others, was much interested in the reference to the revenue phase of the sludge drying and the net costs of operation. Mr. Wyman explained that the accounting system is a little unfortunate, inasmuch as construction has been going on ever since the plant began, and in the auditing department it has been easy for operating and capital expense to become interchanged. It was obviously unfair for anyone to think that the revenue from the sludge carried the whole plant operation, but he was sure it would carry all the expense of drying; but it was not clear whether it would cover the expense of the sludge filtering ahead of drying. Since, aside from the success of carrying on the process without offense is the cost of doing it, and especially the sludge expense, it seemed that the Association could do a service by obtaining and presenting these costs as understandingly as possible. Accordingly, at the request of the editorial committee, Mr. Goudey has gone into the records and gives the following figures:

GENERAL DATA

Present population sewered 114,000
Present average sewage flow ..... 7 m.g.d.
Ultimate population 157,000
Ultimate average sewage flow ..... 11 m.g.d.
Aeration tanks, capacity 2.25 m.g.; re-aeration tanks, 0.37 m.g.; final clarifiers, 1.12 m.g.

The costs to be presented are intended for their usefulness elsewhere. Hence certain development expense incidental to a pioneer enterprise and not affecting the present basis of operation is omitted. However, that the full cost data as it is carried in the city comptroller's books may be made known to all, all items in the comptroller's report not used here are itemized at the close of this discussion.

CAPITAL EXPENSE

Original investment, for construction and design, 1923	$447,249.52
Additions and remodeling, 1924, to Sept. 30, 1928	279,926.05
Total capital cost to Sept. 30, 1928	$727,175.57

Hence cost per m.g.d. capacity, present, $104,000; ultimate, $66,000; and cost per capita, present, $6.37; ultimate, $4.63.

OPERATION EXPENSE

These figures are based on the operating costs July 1, 1928, to September 30, 1928, inclusive, during which time the plant has been operating under normal conditions reproducible elsewhere. They allow for bills outstanding September 30, 1928. No allowance is made for anticipated economies in use of chemicals based on experimental work in progress. During that period the governing operating data were as follows:

Principal Operating Data, July 1, 1928, to Sept. 30, 1928

Total sewage treated in period	615,700,000 gal.
or 6.7 m.g.d.	
Air used	1,292,340,000 cu.ft.
or 2.1 cu.ft. per gal.	
Electrical power all purposes	1,214,800 kw.hr.
Liquid sludge filtered	23,973,000 gal.
or 39,000 gal. per m.g. of sewage flow.	
Filter cake produced (80% water)	3,223 tons
Water evaporated	2,578.4 tons
Dried sludge produced	644.6 tons
or 1.05 tons per m.g. Note—On a year's basis, with average sewage flow 7.0 m.g.d., sludge produced would average 1.2 tons per m.g. During the spring, sludge production is highest and in summer lowest.	
Alum used, 226,500 lb. or	113.2 tons
Celite used, 265,000 lb. or	132.5 tons
Chlorine (for sewage disinfection)	13,524 lb.
Gas for drying sludge	118,000± cu.ft.
Gas for burning drier gases	82,000± cu.ft.

Operation Costs (per 1,000,000 gallons)

	July 1, 1928, to Sept. 30, 1928 6.7 mgd.	Present flow av. 7.0 mgd.	Plant capacity 11 mgd.
(A) Screening, aeration, clarification and chlorination:		Est.	Est.
Labor, 3 men at $175 per mo.; 1 at $6.75 per day; 1 at $5.00 per day; 1 at $4.00 per day	$ 4.39	$ 4.11	$ 2.68
Power av. 0.88c per kw.hr. (pres.)	14.60	14.60	14.60
Chlorine 22 lb. per m.g. at 6c lb.	1.32	1.32	1.32
Miscellaneous oil and grease	0.08	0.08	0.08
Maintenance and renewals	0.57	0.57	0.57
Portion of general expense	2.01	1.92	1.23
Sub-total, aerating, cl., etc.	$22.97	$22.50	$20.48
(B) Sludge conditioning, and filtration:			
Labor, 26 days per mo.; 1 man at $5.00 per day; 1 at $4.50; 3 at $6.75	$ 3.88	$3.72	$ 2.37
Power av. 0.88c per kw.hr.	1.81	1.81	1.81
Alum 368 lb. per m.g. at 1.6c lb.	5.90	5.90	5.90
Celite 431 lb. per m.g. at 1.47c lb.	6.35	6.35	6.35
Oil, grease, tools	0.12	0.12	0.12
Filter cloths, $150 every 4 mo.	0.18	0.18	0.18
Maintenance and renewals	0.49	0.49	0.49
Portion of general expense	1.80	1.72	1.10
Sub-total sl. cond. and filt.	$20.53	$20.39	$18.32

	July 1, 1928, to Sept. 30, 1928 6.7 mgd.	Present flow av. 7.0 mgd.	Plant capacity 11 mgd.
(C) Sludge drying, exhaust gas burning, and storage of sludge:		Est.	Est.
Labor part time, 3 at $6.75 per day; 3 at $5.00; 2 at $4.50 per day	$ 4.55	$ 4.35	$ 2.76
Power av. 0.88c per kw.hr.	0.93	0.93	0.93
Sacks at 0.08	1.66	1.66	1.66
Gas for drier, at 17.5 per 1000 cu.ft.	2.94	2.94	2.94
Gas for burning exhaust gas at 17½ per 1000 cu.ft.	2.03	2.03	2.03
Miscellaneous, oil, and grease	0.04	0.04	0.04
Maintenance and renewals	1.04	1.04	1.04
Portion of general expense	1.27	1.22	0.77
Sub-total sludge drying	$14.46	$14.21	$11.87

Summary Items (A), (B), (C)

(A) Screening, aeration, clarification, chlorination	$22.97	$22.50	$20.48
(B) Sludge conditioning	20.53	20.39	18.32
(C) Sludge drying, storing, exhaust gas burning	14.46	14.21	11.87
Total (A), (B), (C)	$57.96	$57.10	$50.67
Less revenue from sale of sludge 1.2 tons per m.g. at $25.25 per ton (contract)	30.30	30.30	30.30
Net operating cost per m.g.	$27.66	$26.80	$20.37

Investment costs appearing in comptroller's account, but not included in the foregoing cost data:

Water and gas extensions	$ 1,454.00
Irrigation pumps	7,528.88
Road	1,922.19
Pump house	3,705.77
Tearing out MacLachlin press	794.22
Condemnation proceedings, Rio Honda outfall	5,102.97
Outfall sewer to plant	23,520.90
Protection to creek banks	200.00
Road	206.45
Rio Honda outfall	122,717.70
Starting equipment (depreciation)	796.15
Sludge burying equipment (emergency)	3,350.43
Experimental work, included in an item of $9,344.04 and estimated at	5.000.00
Total	$176,299.66

Operating costs appearing in comptroller's accounts, but not included in foregoing cost data:

Item 38-1	(salaries total $4,627.10). Of this, $1923.60 was not for regular operation	$ 1,923.60
	Mechanics and electricians (new work)	1,095.77
	Salaries, city engineer	450.00
	Salaries, experimental work (now ended)	514.23
	Labor jobs, 1130-1131 (experiment)	246.81
	Repairs to vehicles (sludge burying stopped)	124.80
	Repairs and maintenance, $592.84, reduced because not normal monthly expense	242.84
	Small tools (new construction)	19.23
	Fuel, oil, gas, $250.05, mostly for sludge burial	200.05
	Membership, C.S.W.A.	2.00
Item 38-2	Repairs, etc., $896.87, reduced to $412.50 since this was partly an annual repair and cloths last 4 mo.	484.37
Item 38-3	Entire item, method obsolete	2,789.31
Item 38-4	Repairs, $1,085.12, not ordinary expense entirely	385.12
Item 38-5	Rentals, experimental	56.80
Items 38-6 to 8, inclusive, no longer practiced		909.30
	Total	$ 9,444.23

Outline of Tests Demonstrated at the California Sewage Works Association

San Bernardino, October 10, 1928

By E. A. Reinke*

SETTLEABLE SOLIDS TESTS

This test gives a measure of the solids removed in settling tanks.

Equipment**—Two Imhoff tubes of 1 litre capacity.

Procedure—

(1) Collect samples of raw and settled sewage and put exactly 1 litre of each in separate Imhoff tubes, making sure that large solids and paper are broken up.

(2) Stand the tubes vertically in prepared frames.

(3) After about 15 minutes note sides of tubes and if solids are clinging then tap or stir gently to release and allow to settle.

(4) After one hour's settling read the volume of solids and record results as cubic centimetre per litre. If the surface of the solids is not quite level an average reading is taken.

Empty the tubes and fill with clean water to prevent grease from filming on the sides. Accumulation of grease may be removed by washing tubes with kerosene or gasoline.

This test is also useful to the engineer designing a tank. Plotting the cubic centimetre readings for sludge level at, say, 15-minute intervals, will show the readiness with which all settleable matter settles.

FREE CHLORINE TEST

This test measures the active chlorine remaining in solution at the time of testing. If free chlorine is present it throws light on the unnecessary excess of chlorine which is being applied; and if present in a certain amount, to be determined in each case, it is a good indication that disinfection is being obtained. The chlorine remaining, say, 5 minutes after its appli-

*Assistant Engineer, Bureau of Sanitary Engineering.

**These may be ordered as follows: Braun-Knecht-Heimann Co., 576-584 Mission St., San Francisco (The Braun Corporation, Los Angeles) B-K.H No. 63840 Cone, Settling Glass, Imhoff, each $4.25 list, or equivalent from other laboratory supply houses.

cation should be 0.5 lb. per mil. gal. or better. A check against bacterial analysis will establish the exact amount.

Reagent—Orthotolidin solution.

Equipment*—Standard comparison tubes or bottles. Empty tubes or bottles graduated to 100 c.c., 1-c.c. pipettes.

Procedure—

(1) Collect exactly 100-c.c. sample.

(2) Add 1 c.c. orthotolidin solution and mix. Allow to stand 5 minutes.

(3) Compare color with standards.

If liquid is colored or turbid collect duplicate samples and add tolidin solution to one. Hold the other behind the standards to offset color or turbidity normally present.

If nitrites, manganese, iron or other interfering substances are present false readings will be obtained. Their presence can usually be determined by testing the sewage or effluent with the reagent before chlorination, to see if a yellow color is obtained.

pH TESTS—HYDROGEN-ION CONCENTRATION

This test measures quantitatively the acidity or alkalinity of a given sample. It is far more sensitive than the use of litmus paper. A reading of pH 7.0 corresponds to neutral, above 7.0 is alkaline, below 7.0 is acid.

Reagents—Indicator solutions. Brom thymol blue most common.

Equipment**—Test tubes graduated to 10 c.c.

1-c.c pipettes.

Color comparison tubes corresponding to various indicators.

(1) Collect exactly 10-c.c sample in test tube.

(2) Add 1-c.c indicator solution and mix.

(3) Compare color with standards.

Liquid must be reasonably translucent. If liquid is turbid fill one tube with liquid and hold it behind standard, placing a tube of distilled water behind sam-

*Standards may be ordered from: La Motte Chemical Products Co., McCormick Bdg., Baltimore, Md. La Motte-Enslow Chlorine Comparator, each $12.50 list, or equivalent set.

**Standards may be ordered from: La Motte Chemical Products Co., McCormick Bdg., Baltimore, Md. La Motte Block Comparator, Model N E Brom Thymol Blue Range, each $12.50 list.

ple to get the same effect from turbidity in each sample.

(4) Record results as pH number on standard color tube most nearly corresponding to sample.

Procedure for Sludges—

(A) Filter sample of sludge through a good grade of absorbent cotton or through filter paper washed free of alkali with distilled water. Test the distilled water as filtered to ascertain that it is as acid as the original distilled water. Distilled water is acid. The filtration through cotton is obviously the more simple and rapid.

(B) Collect filtered liquid, after it begins to filter clear or reasonably clear, with a minimum drop through the air, as carbon dioxide will be given off which may materially change the pH value.

Continue from step (1) above.

RELATIVE STABILITY OF EFFLUENTS

This measures the stability or degree of oxidation of a sewage effluent. It actually measures the proportion of oxygen available to that demanded by a sample. When the blue color disappears it shows that the oxygen, whether as free oxygen, nitrates, or any other available form, has been used up. The time within which decolorization occurs gives an index figure for the relative stability. The test is not useful on raw sewage or on sewage which has been simply settled, but rather on oxidized sewages or polluted waters.

Reagent—Methylene blue, 0.5 gram double zinc salt or commercial variety dissolved in 1 litre of distilled water.

Equipment*—Clear, glass stoppered bottles of 150-c.c. capacity.

Pipettes graduated to 0.4-c.c.

Procedure—

(1) Collect samples in clean bottles, being careful to fill without entraining air.

(2) Add exactly 0.4-c.c methylene blue solution, holding the tip of the pipette just below the surface of the liquid. Do not blow out the last portion, as this adds air to the sample.

*These materials may be purchased from any laboratory supply house.

(3) Stopper carefully, mix, and incubate at 20° C. For accurate work a water seal against absorption of air should be made by slipping a rubber collar over the neck of the bottle reaching above the top of the cork and filling with water.

(4) Observe the sample twice daily until decolorization occurs. Incubation for ten days is usually sufficient, as that period of decolorization indicates a high degree of stability. Record results according to the following table:

Period of Incubation (Days)	Relative Stability (20° C.)	(37° C.)
1	20	40
2	37	63
3	50	78
4	60	87
5	68	92
6	75	95
7	80	97
8	84	98
9	87	99
10	90	99+

Bottles must be thoroughly cleaned before use. If the effluent is turbid the color will be absorbed and precipitated and the results are useless.

If the operator suspects that lime, lye, chlorine, or other disinfecting chemicals are being used or are present in the sewage, the blue color may remain indefinitely even in a raw sewage, because the sample is sterile. The result is therefore useless. In such cases the test can be used only by neutralizing the sample and reinoculating.

SEWAGE SLUDGE AS FERTILIZER

The entire output at Schenectady, New York, during 1927, was sold for this purpose. It has been used now for four years on parks and gardens, and is being tested on golf courses. In Ohio, Marion is the only municipality that markets its sludge. Beginning a year ago sales at $4 a load have steadily increased. At Canton the wet sludge is pumped with such success to a large farm owned by the city, that there is now a heavy demand from neighboring farmers.—(Mun. News & W. W. Aug. 1928.)

Sewerage Systems and Treatment Plants at Lake Arrowhead, San Bernardino County

By Morris Ellinger*

There are two sewage disposal plants at Lake Arrowhead, one for the south side of the lake which includes the 'Village' of Lake Arrowhead, and the other plant for the north side of the lake. These complete sewerage systems and treatment plants were constructed, and are owned by the Arrowhead Lake Co.

Imhoff Tanks at South Side Sewage Treatment Plant, Lake Arrowhead

to care for the development of their property surrounding Lake Arrowhead. This property is thickly wooded and mountainous.

The main sewer lines, constructed in sections of 5000 feet, follow the contour of the land to a great extent. A pumping station equipped with two automatically operated, electrically driven pumps, is installed at the end of each section. These pumps lift

*Assistant Engineer, Arrowhead Lake Co.

the sewage 15 ft. to the next section. The main sewer line of the south-side system is practically all 12-in. cement-concrete pipe with a grade of 0.3 ft. per hundred. There are many 6 and 8-in. laterals conducting the sewage down to the main line. In laying sewer lines among the trees here, great care has to be taken to make a tight joint in the pipe to exclude the tree roots as much as possible, otherwise they would clog the sewer lines. So far the tree roots have not caused trouble in this respect.

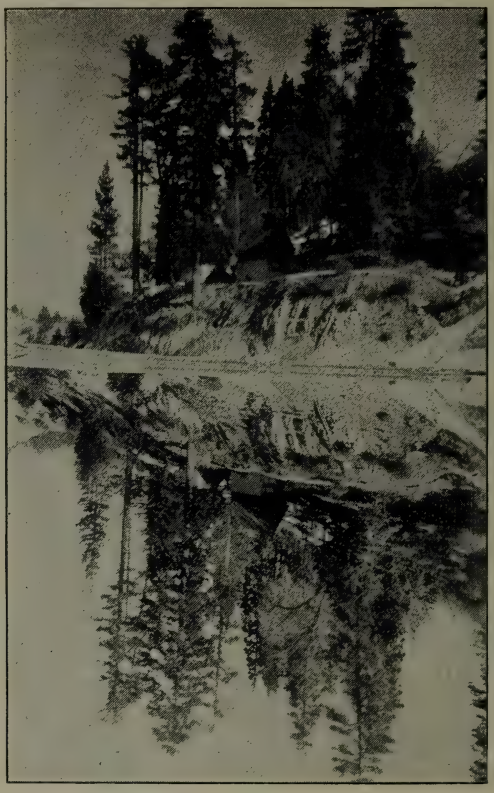
The treatment plant for the south side consists of two Imhoff tanks, and a series of five settling ponds, which are on flats below the tanks. The water varies in depth down to 4 ft. in the ponds. Some of the

Sedimentation Ponds at South Side Sewage Treatment Plant, Lake Arrowhead. No. 1 is Large Pond at Right; No. 2 is Distant Pond; No. 3 is Pond at Left; No. 4 Small Pond in Foreground; No. 5 is on Ledge Below (Not Visible)

water evaporates and the remainder seeps into the ground. There is no direct discharge into the creeks from either plant.

The Imhoff effluent runs into pond No. 1, capacity of which is 1,800,000 gal., where some of the water evaporates or seeps into the ground. There is an adjustable weir between ponds No. 1 and No. 2, so that the water can flow to the latter pond which has a capacity of 1,700,000 gal. Here the water is allowed to stand until bacteriological analyses show a great reduction in bacteria, when it can be discharged into pond No. 5, capacity 600,000 gal. There are no dis-

charging facilities from this pond, because evaporation and seepage have been adequate for the flow of water, and probably will be for a few years. By opening a valve in the levee of pond No. 1, the water can be run into ponds No. 3 and No. 4, having capacities of 900,000 and 300,000 gal., respectively. Then after showing the desired reduction in bacteria can be run into pond No. 5. The water cascades when running



Pond No. 1, with Imhoff Tanks on Bank, South Side Sewage Treatment Plant, Lake Arrowhead

into this pond, as it is on a flat below the other ponds. The evaporation is about 36 in. per year.

The sewage flow to the south-side treatment plant varies from a daily mean of 10,000 gal. per day in the winter, to 100,000 gal. per day in the summer, with a maximum flow of 300,000 gal. per day.

The sewage flow at the north-side treatment plant varies from 5000 gal. per day in the winter to 25,000

gal. per day in the summer, with a maximum flow of 55,000 gal. per day.

A sludge bed is provided for each Imhoff tank. The dried sludge is used as a fertilizer with good results at the Lake Arrowhead golf course.

The north-side treatment plant consists of an Imhoff tank, sprinkling filter bed, dosing tank, final settling tank, chlorinators and settling pond. The Imhoff tank was designed for a population of 2000, or an average flow of 100,000 gal. per day.

The Imhoff effluent runs into the dosing tank and is then sprayed over the crushed rock filter bed. Thirteen Taylor spray-nozzles are used on the filter bed. After draining from the filter bed the water is chlorinated with a dose varying from 10 to 30 lb. per million gallons. Three chlorinating machines of the manual control type are installed, two of which are in use simultaneously, and the third for use in case of accidents and when overhauling the other machines. The two diffusers in use are placed in the intake to the settling tanks so that all the flow comes in contact with the gas before entering the final settling tank. The effluent from this tank is conducted to a settling pond where the only escape is by evaporation and seepage. There is no direct seepage into the creek which is close by.

A recording water stage register is installed in each Imhoff tank to measure the Imhoff effluent.

In the operation of the Imhoff tanks the scum in the gas vent compartment is broken and mixed by the use of a tool, that is constructed heavier and stronger, but otherwise similar to a rake without teeth. This same tool is used to scrape down the walls of the settling compartment. A water hose is available at each Imhoff tank, but this is seldom used to break the scum. Past experiences indicate that the digestion of the organic matter, and formation of digested sludge is speedier, and general operation of the Imhoff tanks more satisfactory when no water is added direct to the scum compartment. This also has a tendency to decrease the depth of the scum. During the five years that these treatment plants have been in use only one case of foaming has occurred. This was caused by the overloading of the Imhoff tank during the heavy

summer flow when there was only one tank at the south-side plant.

Freezing weather is experienced at the treatment plants as Lake Arrowhead is about a mile high. The north-side plant is located in a canyon where lower temperatures prevail than closer to the lake. In freezing winter weather the sprinkling filter bed is not operated as, at this time of the year the sewage flow is small, and the efficiency of the filter bed is greatly reduced by ice forming on the top of the bed.

Laboratory tests of the chlorinated sewage practically always show that 100 per cent of the bacteria have been destroyed.

A laboratory is maintained at the lake to check the operation of the treatment plants, by the reduction of bacteria in the sewage. Bacteriological analyses are also made of the creek waters running into Lake Arrowhead, the domestic water supply and reservoirs.

A record of the operation of each treatment plant is kept on suitable record forms. These record sheets show the sewage flows, operation of the Imhoff tanks, sprinkling filters, chlorinating control apparatus, and quantity of water in the ponds. Separate forms are used to show the laboratory results of the treatment plants, the reduction of bacteria, suspended matter in effluents, and putrescibility.

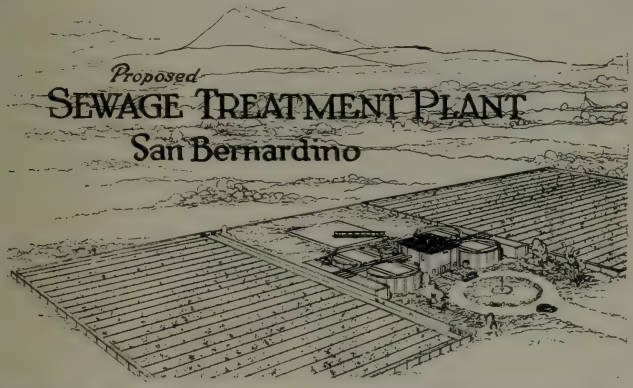
ODOR CONTROL

Screens of natural forest trees about plants, prevent transport of odors. Trees and shrubs furnish cool, moist leaf surfaces, on which odoriferous vapors are condensed, and themselves give off pleasant odors that tend to disguise those of an offensive nature from the plant. "The nerve sensation called smell may be forgotten if other interests are paramount."—J. F. Skinner. Most sewage plant odors "are the result of over-active imagination".—(Cohn.)

Ferrous sulphate applied (25 p.p.m.) to the raw sewage prevents the formation of sulphureted hydrogen, the production of which varies during the day, dropping (at Haddonfield, N. J.) after 1 a.m. until 3 p.m. and then increasing to a maximum at 8 p..m—(Sparmaker & Forman.)

San Bernardino's New Sewage Treatment Plant*

'Impossible!' you say. Yet visualize, if you can, what is being accomplished by the city of San Bernardino—the taking over of about forty acres of low, swampy land, transforming it into a dry, grassy, park-like space, and then, in the center of that park, disposing of sewage from a city of 40,000 people, without giving offense, either visual or odorous, to people across the street. In addition to that—and here is the most wonderful part of the miracle from the tax-



Architect's Drawing; Accurate Except That Secondary Clarifier Will Be Round Instead of Square. Outfall Sewer to Plant Will Be a Three-Pipe Inverted Siphon of Hume Concrete Pipe

payers' viewpoint—the city will make the revenues derived from the sale of purified sewage from this plant pay substantial dividends on its entire investment.

The plant proper is about one mile south of the city, and is connected with the main sewers in town by a huge inverted siphon. This siphon—over a mile long—is constructed of three separate lines of specially made concrete pipe of 15, 18 and 24-in. diameter. These pipes receive the sewage from the outfall, and any or all of them are automatically cut into or out of service, according to the quantity of sewage reaching them. In spite of the fact that the plant end of the siphon has a vertical lift of 17 ft., the automatic regulation of the velocity of flow is such that the settling of solids anywhere along its length is impossible.

*Reprinted from Program of League of California Municipalities.

Facilities are provided for the introduction of chlorine into the sewage at three separate points—namely, the upper end of the siphon, the entrance to the Imhoff tanks, and the entrance to the dosing chambers. This procedure—called pre-chlorination—absolutely eliminates all odors. While pre-chlorination systems have been successfully added to many existing plants, it is interesting to note that this is the first original design in the United States to embody this feature.

Another remarkable thing about the plant is that the gas formed by the natural decomposition of the solids settled from the sewage, which amounts to approximately one-half cubic foot per capita per day, is one of principal causes of odors in sewage treatment. These odors will be eliminated by the collection, storage, and burning of this gas. All power and lights necessary in the operation of the plant will be furnished by utilizing the gas to produce electrical energy. This gas has a heating value of between six and seven hundred B. T. U., about the same as any artificial gas.

The process of sterilization and deodorization need not be dwelt on here, except to say that it is nearly 100 per cent efficient, and it will be kept so by a constant series of laboratory tests. For this purpose the plant will be provided with a completely equipped chemical laboratory. The next step is the separation of the solid and the liquid contents of the sewage. After complete digestion of the solids they will be spread over sand beds within the plant and thoroughly dried. After drying, they are removed from the sludge drying beds by mechanical overhead litter carriers, loaded directly into trucks, and sold as mulch, or low grade fertilizer. The effluent, or liquid content of the sewage flows from the plant at the rate of about 300 miner's inches. This is of very great value for irrigation and its sale should produce an income sufficient to pay a good rate of interest on $500,000, while the plant which produces it cost only $343,000.

Other things which will tend to make this plant one of the most efficient and economical in existence, are the provisions for handling and storing a carload of one-ton containers of chlorine, thus cutting the cost of this chemical gas from 8½ to 5½ cents per pound,

and the installation of mechanical skimmers to skim the flow of sewage through the chamber.

The park-like appearance is gained by the complete sodding and parking of nearly forty acres of ground around the plant proper; the laying of about 50,000 feet of permanent paving, and the construction of an ornamental gate in a non-climbable fence which is being erected around the entire site. While the present population of San Bernardino is only about 40,000, this plant is designed for a future population of 60,000, and on this basis its entire cost is only $5.72 per capita.

The Currie Engineering Company, with F. S. Currie and C. E. Johnson in charge, are the designers and supervision engineers.

CHLORINATION OF RAW SEWAGE TO SUPPRESS ODOR

Experiments were carried on in 1927 at Neodesha, Independence, and Emporia, by the Kansas State Board of Health. The water at the first two places is at times high in sulphates and, due to this and the septic condition of the sewage, the odor from the trickling filter plants was objectionable.

At Neodesha good results were obtained by dosing the 400,000 g.p.d. average (550,000 g.p.d. max.), flow with a maximum dose of 12 p.p.m. chlorine, or from 40 to 25 lb. per day. Since then with an average dose of 22.3 lb. per day no complaints from odor have been received.

At Independence the flow averages 1 m.g.d. By applying an average of 27.7 lb. chlorine per day as required, the usual requirement during dry weather being 10 p.p.m., odor was prevented at a cost, with chlorine at 12¢ per lb., of $3.32 per million gallon.

At Emporia the average rate of flow from 8 a.m. to 8 p.m. was 920,000 g.p.d., and the maximum rate for 4 hours was 1.1 m.g.d., although the tanks were designed to handle a maximum flow of but 800,000 g.p.d. The sewage is stale and odorous and foaming is troublesome. Applying 15 p.p.m. chlorine at the inlet no residual was found 3 ft. away. The difficulty was practically eliminated by properly baffling the flow in the tank.—(Eng. Bul. No. 16, Univ. of Kan., Feb. 1, 1928.)

Pomona Sewage Works

By Alva J. Smith*

The essential features of the plant are as follows:

An Imhoff tank 45 by 52 ft. in plan, by 35 ft. deep, with a 5-ft. free-board. The unusual height of free-board was provided to take care of the excess of scum that is formed when activated sludge is digested in conjunction with settled sludge, in an Imhoff tank.

A mixed liquor channel in which the effluent from the Imhoff tank is mixed with newly aerated sludge.

Two spiral-flow aerating tanks 16 by 200 ft. in plan, by 16 ft. deep.

Two final settling tanks 30 by 30 ft. in plan, 12 ft. deep, equipped with Dorr clarifiers.

A sludge re-aeration tank.

A chlorination tank.

A power house, equipped with motor driven pumps and blowers, and housing the sludge diversion equipment, the chlorination equipment, meters, and laboratory.

Two sludge drying beds, with a total area of 9600 sq.ft., or approximately 0.5 sq.ft. per capita.

The plant was designed for a population of 20,000, with a sewage flow of 75 gal. per capita, or 1,500,000 gal. per day of domestic sewage. The plant was placed in operation July 1, 1926, and is now operating on a load of approximately 1,000,000 gallons per day, or two-thirds of its designed capacity.

The cost of operating the plant when carrying two-thirds of its designed load is about $24 per million gallons. This cost will be considerably reduced, however, when the supply of sewage is sufficient to give the plant its full load.

An interesting feature in connection with the operation of this plant, which treats the sewage from Pomona, Claremont, and La Verne, is the fact that the revenue derived from the sale of the effluent for irrigation purposes and the sludge as a fertilizer, goes a long way toward paying the costs of operation.

*Engineer in charge of Los Angeles office of Black & Veatch, consulting engineers, Kansas City.

Joint Treatment Plant of Los Angeles County Sanitation Districts

By A. K. Warren*

The 'Joint Disposal Plant' of the Los Angeles County Sanitation Districts, in the extreme southwestern area of the county, has been constructed as the treatment unit in the comprehensive Metropolitan sewer system, serving the area to the south of the city of Los Angeles, embracing approximately 170 square miles.

The plant is unusual for two features in its design. First, that it is designed as a sedimentation plant for future use with an ocean outfall, and is now serving as an activated sludge plant for use with inland discharge of effluent. The modifications which permit such change in operation are all superimposed on the original structure, and readily removable when occasion demands. The other feature which is worthy of comment is the system of air diffusion. This is done through galvanized iron pipes placed in the tanks along one side of the tank bottom, the air being discharged from the pipes through minute holes drilled in copper plates soldered over larger holes in the galvanized iron pipes. The spiral flow feature is incorporated, and with this system of air diffusion the original installation is not only much less expensive than with permanent filtros plates, but the air diffusers are readily removable, accessible for cleaning, and give efficient results comparable with filtros plate diffusion.

To accomplish the change in treatment, pumps were installed to elevate the sewage to a proper depth in the aeration tanks. The sewage is lifted from a wet well, which will serve the ultimate plant as a bar screen well, into presedimentation tanks, which will ultimately be used as grit chambers in the sedimentation plant. From the presedimentation unit, sewage flows into what will ultimately be used as sedimentation tanks in the final plant but in which air diffuser pipes have been installed for temporary use in the activated sludge process. From these tanks sewage flows into final clarification tanks, which will ultimately be used for sludge digestion or for settling

*Chief Engineer, Los Angeles County Sanitation District.

tanks as necessity arises. The plant effluent is returned through a three-mile pipe line to be discharged in Nigger slough, flowing thence into Los Angeles harbor. The activated sludge and the material settling out in the presedimentation tanks is discharged directly onto sand beds for air drying.

At full capacity, the detention period for the sedimentation process will be one hour. At the present time each group of five sedimentation tanks is to be used as four aeration channels and one reaeration channel in the activated sludge process, providing for a five-hour detention period, at 3 m.g.d. capacity.

Joint Disposal Plant of Los Angeles County Sanitation Districts at Harbor City

The first unit to be constructed consisted of the two presedimentation tanks or future grit chambers, 12½ ft. wide, 10½ ft. deep, and 50 ft. long, equipped with Link-Belt bottom sweeps; four aeration tanks (future sedimentation tanks), 12¼ ft. wide, 12½ ft. deep, and 170 ft. long; one reaeration channel (future sedimentation tank), 12¼ ft. wide, 12½ ft. deep, and 163 ft. long; and two clarification tanks (future sedimentation tanks or sludge digestion chambers), 35 ft. square and 12½ ft. deep, equipped with Dorr clarifier mechanism. This unit was presumed to treat 3 m.g.d. at six hours detention, on the basis of 1½ cu.ft. of air per gallon of sewage treated. It has been found, however, that the unit's capacity for the production of a good clear effluent and well conditioned sludge is approximately 4½ m.g.d., at a correspondingly lower air consumption and retention period. This is probably due to the high efficiency of the presedimentation tanks where an average of 67 per cent of the settleable suspended solids are removed prior to aeration.

In addition to the first unit constructed, the districts

now have ready for service two similar additional units similar in every respect to the first unit described. The plant capacity is now estimated at 15 m.g.d., activated sludge process. The present daily average sewage flow approximates 4½ million gallons.

Sludge, both from the presedimentation tank and the final clarification tanks, is being discharged directly onto beds for air and sun drying. It is sold through a commercial fertilizer company for use in orange groves and other areas of fertilization. The districts are now netting a fair return from the sale of sludge.

Laboratory control of the plant is carried to the extent of determining the hydrogen-ion concentration, alkalinity, D.O. of incoming raw, settled, and final effluent, relative stability and suspended settleable solids of incoming, settled, and effluent. Commercial laboratory analysis is made of total nitrogen content of dried sludge sold.

INDUSTRIAL WASTES, CHICAGO SANITARY DISTRICT

Packing House Waste is best treated by activated sludge with 9-hour aeration and 3.5 cu.ft. air per gallon. The sludge is dewatered in a recessed plate press.

Tannery Waste—Biological treatment is uneconomical. For most places screening and sedimentation are recommended. Alum as coagulant is being tried.

Starch Factory Waste—Neither Imhoff tank sedimentation nor activated sludge proved satisfactory, but trickling filtration at 700,000 g.p.d. per acre was successful.—(Pub. Hlth. Eng. Abs. July 7, 1928.)

SLUDGE DIGESTION

"In dosing acid tanks with lime, it is wasteful and futile to undertreat." Samples of undigested sludge taken 1 or 2 ft. above the sludge line are not satisfactory criteria for lime dosing. The sample should be of the sludge itself. The quality of lime used is important where large quantities are used. "Hydrated lime of high magnesium content is the most economical reagent for neutralizing acidity."—(W. Donaldson.)

The Prevention of Odor Nuisance in the Disposal of Creamery Wastes by Treatment With Chlorine Preliminary to Broad Irrigation

By E. A. REINKE*

The production of offensive odors commonly associated with the disposal of creamery wastes is one of the vexing problems confronting the dairy industry. Recent investigations by the Bureau of Sanitary Engineering of the California Department of Public Health indicate that these odors may be prevented, economically and effectively, by chlorination of creamery wastes while fresh, followed by broad irrigation. A creamery at Wasco, California, producing butter, cream, milk, buttermilk, cottage cheese, condensed skim milk, and powdered skim milk, and buttermilk, has successfully disposed of its wastes in this manner for a period of three months. With chlorine at 7½ cents per pound delivered, the cost of chemical for the total flow of 125,000 gal. daily of wastes from 60,000 lb. of raw milk handled, averages $1.50 per day, which is equivalent to 5 cents per ton, or 0.02 cent per gallon. The total cost of disposal is estimated at $7.15 per day, or 24 cents per ton. Investigations at Tulare indicate similar results with even lower costs.

Retarding development of odors in the waste, and providing for quick absorption, are the important points. In the case to be described, the waste, in furrows, quickly drained within a few minutes to 24 hours without causing nuisance. We think the water should not be allowed to lie in the furrows over 12 hours. At one time following a heavy rain, the treated waste diluted with drainage water remained on the surface for three days without producing offensive odors.

WASCO CREAMERY & CONSTRUCTION COMPANY

Plant and Sewer Farm—This company operates a 30-ton per day creamery at Wasco, a town of about 2000 population, without a sewer system, situated in

*Assistant Engineer, Bureau of Sanitary Engineering, California Department of Public Health.

the arid district in Kern county. The community is entirely agricultural and the town is centered around the creamery. The creamery constructed its own sewer, about 3000 ft. long, flowing by gravity to a piece of land in one corner of the town. The wastes average one hour old as they reach the farm.

The farm is composed of soil varying from fairly tight material to loose sandy loam. It is underlain with coarse sand at depths of 8 to 12 ft. Annual rainfall averages 4.5 in., and ground-water level, while not definitely known, is below 15 feet.

Irrigating with Treated Dairy Waste Effluent at Wasco, May 31, 1928; Looking East

Management of Farm—The farm consists of 13 acres of land owned by the company, and 2½ acres which are rented, making a total of 15½ acres on which 125,000 gal. of waste are handled daily. The rate is therefore about 8000 gal. per acre per day. The entire farm is prepared with plowed furrows, and during the present summer is planted to corn. While the corn was young the land was frequently cultivated, but after the corn got higher the waste was run into the same furrows repeatedly without breaking up the surface. Although the farm is leveled to some extent, there are low spots in which the waste has at times collected; and when it remains in these spots longer than 24 hours, a dank or musty odor can be noted, sometimes extending for several hundred feet.

History of Odors—The nuisance around the farm used for disposal of creamery wastes at Wasco was first brought to the attention of the Bureau in 1923, and frequently complaints have been received since that date. Unfortunately the farm is so situated that

prevailing winds carry odors over a portion of the town. The first operations of the farm consisted of storing the night-flow and using the combined day and night-flow on alfalfa during the day. The odors were very offensive. The Bureau advised abandoning the septic tank, running the wastes fresh to the farm, and irrigating both night and day. This relieved the nuisance to some extent, but as the farm was privately owned, the creamery had no control of the handling of the wastes, and the odors were still very offensive. The creamery then arranged a pipe distribution system, replacing ditches to keep the waste under the

Irrigating with Treated Dairy Waste Effluent at Wasco, May 31, 1928; Looking South

ground until actually used, but this did not relieve the nuisance. Various methods of handling were tried under private management, without success, and the creamery finally bought the farm. About a year ago the creamery management had come to the conclusion that the farm should be run primarily for waste disposal, the growth of crops being only incidental, and the farm was leveled and plowed to get the waste underground as quickly as possible. An additional area of 2½ acres adjoining the farm was rented. In spite of all these precautions, the odors persisted and were more offensive because of larger volume due to growth of the creamery.

LABORATORY EXPERIMENTS

In the spring of 1928 we suggested to the manager of the creamery that chlorination of the fresh waste might delay decomposition long enough to allow its disposal underground without production of offensive odors, and collected a sample of the waste, which was taken to the laboratory for experimental purposes. The waste was treated with various doses of chlorine,

and it was found that a dose of 20 parts per million for the sample obtained caused a marked decrease in odors. The results were so promising that arrangements were made through the Wallace & Tiernan Co. and the Great Western-Electro Chemical Co. to carry on full-scale experimental work in the field in accordance with an arrangement made with the Chlorine Institute for studies on sewage disposal last year.

Effect of Chlorine on Crops—Another set of experimental studies was carried on in the laboratory in connection with the use of chlorinated sewage for crops, to find what doses of chlorine would affect young plants. Field corn, kafir corn, peas, lentils, wheat, and sunflowers were grown in pots and in culture solutions, and treated with varying doses of chlorine. We learned that in culture solutions as much as 25 parts per million of chlorine could be kept continuously in contact with the plant roots without deleterious effects, and that in pots sprinkled twice daily, as much as 400 parts per million could be used in the sprinkling water, with no apparent effect on the plant. With this experience we were certain that the small residual which might at times be carried in the creamery wastes would not hurt crops on the farm, and subsequently in actual operation the best crop of kafir corn in the vicinity was raised using chlorinated waste.

FIELD EXPERIMENTS

A solution feed chlorinator was set up at the creamery, discharging directly into a sewer, and chlorine started at a dose of about 50 parts per million at 11:00 a.m. on May 4, 1928. This dose was kept up for three days to allow thorough cleaning of the sewer. The odors had been bad for several days, particularly in the early evening. Neighbors reported a slight chemical or medicated odor, beginning on the evening of May 4, which, while not pleasant, was far better than the rotten, nauseating odors that had previously been experienced. Arrangements were made with the neighbors to keep daily records of the character and offensiveness of odors noted. The superintendent of the creamery was instructed to operate for one week at each of several doses, varying from 10 parts per million to 30 parts per million.

The record of these odors indicated that at 15 parts per million, or less, the old odors were experienced;

and that with 25 parts per million, or more medicated or chemical odors were frequently observed. Neighborhood sentiment is positive that the odors have been relieved to a point where they are easily tolerated. The only odor that is common is the 'moist' odor of damp ground, but we can conceive of occasional medicated odors during periods of low or weak flows. It has been found unnecessary to vary doses with each variation in strength and quantity of waste. We have concluded that for present conditions at the creamery a dose of 20 parts per million will be most effective.

COST DATA FOR A 30-TON CREAMERY

The capital outlay is as follows:

Sewer and piping on farm	$1750
Chlorinator	1390
Total	$3140

The estimated costs of operation are as follows:

Chlorine, $1.50 per day (20 lb. per day at 7½¢ per pound)	$ 550 per year
*Water, 2000 gal. per day at 10¢ per 1000 gal.	70 " "
Sewer farm on rental basis, 15½ acres at $40 per acre	620 " "
Operation of farm	1600 " "
Interest and depreciation on pipe and equipment (15% of $3140)	470 " "
Total	$3310

Total cost of handling = $3310 per yr.
Return from crops = 700 " " (estimated)

Net cost $2610 " " = $7.15 per day
= 24¢ per ton or
= 0.096¢ per gallon of milk handled, of which about 24% is chargeable to chlorination for odor control.

*For operation of solution feed chlorinator. At Wasco water for the plant purchased at a flat rate and no extra charge was made for that used in the chlorinator.

LIST OF MEMBERS OF CALIFORNIA SEWAGE WORKS ASSOCIATION—OCTOBER 9, 1928

	Name	Address	City
1.	Adams, Walter H.	County Surveyor's Office	Los Angeles
2.	Albers, J. C.	City Engineer, City Hall	Beverly Hills
3.	Allen, Wm. A.	310 Ventura St.	Pasadena
4.	Banta, A. Perry	202 Law Bdg.	Los Angeles
5.	Barzellotti, L. F.	City Engineer	Lodi
6.	Batty, Frederic A.	C. E., 942 So. Bronson Ave.	Los Angeles
7.	Beale, Ed. W.	739 Fourth St.	San Diego
8.	Bell, Alexander	W. & T. Co., 7 Front St.	San Francisco
9.	Berryhill, R. M.	City Mgr., City Hall	Tulare
10.	Blakely, J. F.	City Clerk	Lodi
11.	Bogart, Dr. Guy	Mayor	Beaumont
12.	Bolton, H. R.	Res. Eng., Box N	Lomita
13.	Bowlus, Fred D.	Res. Eng., Box 182	Downey
14.	Boyd, Geo. H.	Cons. Eng., 1201 Pershing Sq.	Los Angeles
15.	Brown, Robert F.	C. E., 523 Sharon Bdg.	San Francisco
16.	Burgess, Raymond	35 No. Eigleberry St.	Gilroy
17.	Byxbee, J. F.	City Engineer	Palo Alto
18.	Calhoun, Chad. F.	Engineer, 1010 Spring Arcade Bdg.	Los Angeles
19.	Chandler, W. W.	Co. San. Inspector	Santa Ana
20.	Chutter, H. W.	Box 914	Fresno
21.	Collins, W. H.	Eng., Pac. Clay Prod., 1151 So. Bdwy.	Los Angeles
22.	Compton, C. R.	202 Law Bdg.	Los Angeles
23.	Crist, Marion L.	San. Eng., 422 Western Pacific Bdg.	Los Angeles
24.	Currie, Frank S.	219 Andreson Bdg.	San Bernardino
25.	Davies, Donald, Jr.	Asst. City Eng., 437 Pajaro St.	Salinas
26.	Del Gardo, F. O.	Gladding, McBean & Co.	San Francisco
27.	DeLancey, Edward F.	141 So. Cedar St.	Glendale
28.	DeMartini, Frank E.	102 Civil Engineering Bdg.	Berkeley
29.	Donaldson, David	1485 Scott Ave.	Los Angeles
30.	Earle, W. C.	City Engineer, City Hall	Pasadena
31.	Ellinger, Morris	Assistant Engineer	Lake Arrowhead
32.	Enslow, L. H.	The Chlorine Inst., 30 E. 42nd St.	New York
33.	Faulkner, J. D.	705 City Hall	Los Angeles
34.	Foster, Fred F.	419 Grosse Bdg.	Los Angeles
35.	Foster, Wm. Floyd	Eng., Klinker Bdg.	Los Angeles
36.	Froehde, F. C.	City Engineer	Pomona
37.	Fuller, Geo. W.	170 Broadway	New York, N. Y.
38.	Gierlich, O. A.	Bank of Italy Bdg.	Monrovia
39.	Gillespie, C. G.	102 Civil Engineering Bdg.	Berkeley
40.	Goudey, R. F.	823 Associated Realty Bdg.	Los Angeles
41.	Gray, Harold F.	2540 Benvenue Ave.	Berkeley
42.	Grosz, John A.	Operator, 311 East Elm St.	Lodi
43.	Grunsky, C. E.	Cons. Eng., 57 Post St.	San Francisco
44.	Hanapel, A. H.	219 Andreson Bdg.	San Bernardino
45.	Hapgood, E. P.	City Engineer, City Hall	Anaheim
46.	Haseltine, T. R.	422 Western Pacific Bdg.	Los Angeles
47.	Hastings, A. T.	Dorr Co., Ltd., 16 South St., London, E. C. Eng.	
48.	Helgren, E. J.	City Health Officer	Santa Rosa
49.	Hogan, W. B.	City Engineer	Stockton
50.	Hommon, H. B.	U. S. P. H. S., 420 Call Bdg.	San Francisco
51.	Hyde, Chas. Gilman	Civil Engineering Bdg.	Berkeley
52.	Jacobson, Sam	644 Brittania St.	Los Angeles
53.	Jencks, W. L.	419 Grosse Bdg.	Los Angeles
54.	Jenken, Clyde L.	City Engineer	Santa Ana
55.	Jensen, Andrew M.	City Hall	Fresno
56.	Johannsen, John F.	City Eng., 1129 E. Harvard	Glendale
57.	Johnson, C. E.	219 Andreson Bdg.	San Bernardino
58.	Jones, Thomas P. B.	Co. San., Health Dept.	Riverside
59.	Kempkey, A.	1218 Hobart Bdg.	San Francisco
60.	Kennedy, C. C.	543 Call Bdg.	San Francisco
61.	Kivari, A. M.	The Dorr Co., 108 W. 6th St.	Los Angeles

	Name	Address	City
62.	Knowlton, W. T.	City Hall	Los Angeles
63.	Koebig & Koebig	458 So. Spring St.	Los Angeles
64.	Langelier, Wilfred F.	Assoc. Prof., C. E. Bdg.	Berkeley
65.	Linton, Robert	1151 So. Broadway	Los Angeles
66.	Lloyd, Bert	Engineering Dept.	Glendale
67.	Lockwood, F. M.	Mgr. Operations	San Diego
68.	Longacre, Leonard L.	107 So. Meridian Ave.	Alhambra
69.	Loucks, R. L.	City Hall	Oceanside
70.	Lowe, H. E.	704 Wright & Callender Bdg.	Los Angeles
71.	Luippold, G. T.	3923 West 6th St.	Los Angeles
72.	McBride, J. L.	C. E., Ramona Bdg.	Santa Ana
73.	McKay, A. A.	401 Klinker Bdg.	Los Angeles
74.	McMillan, Donald C.	City Engineer, Box 562	Ventura
75.	Mason, John L.	Sharon Bdg.	San Francisco
76.	Oliver, Graydon	819 Santee St.	Los Angeles
77.	Olsen, L. F.	724 So. Spring St.	Los Angeles
78.	Palmer, Harold K.	139 North Broadway	Los Angeles
79.	Pardee, B. J.	City Manager	Visalia
80.	Parkes, G. A.	San. Eng., 1930 Milan Ave.	South Pasadena
81.	Patterson, R. L.	City Engineer	Newport Beach
82.	Perry, Don E.	Manager & Assessor, Box 91	San Anselmo
83.	Pickett, Arthur G.	Klinker Bdg.	Los Angeles
84.	Post, Fred W.	Plant Mgr., Rt. 3, Box 218A	Lodi
85.	Rawn, A. M.	139 North Broadway	Los Angeles
86.	Reed, Howard S.	417 Fleming Bdg.	Phoenix, Arizona
87.	Reinke, Edward A.	102 C. E. Bdg.	Berkeley
88.	Reynolds, Leon B.	Prof. San. Eng.	Stanford University
89.	Roberts, W. C.	543 Call Bdg.	San Francisco
90.	Roen, Otto S.	City Mgr., City Hall	South Pasadena
91.	Sanchis, Jos. M.	2409 Blake St.	Berkeley
92.	Schuyler, Philip	Editor Western Construction News	San Francisco
93.	Shanks, J. King	Gladding, McBean Co.	Los Angeles
94.	Slover, Sutphen	City Engineer	Azusa
95.	Smith, Alva J.	310 Boylston St.	Pasadena
96.	Smith, Chester A.	422 Western Pacific Bdg.	Los Angeles
97.	Smith, Clyde F.	202 Law Bdg.	Los Angeles
98.	Smith, R. E.	San. Insp., 518 So. Dickel St.	Anaheim
99.	Sparling, H. T.	Klinker Bdg.	Los Angeles
100.	Stead, A. J.	City Engineer	Laguna Beach
101.	Steward, O. E.	321 No. Philadelphia St.	Anaheim
102.	Strayer, Elmer C.	C. E., 111 So. Olive Ave.	Alhambra
103.	Tabor, Edwin R.	1201 Pershing Square Bdg.	Los Angeles
104.	Taylor, Carl V. F.	City Eng., 338 Harvard Ave.	Claremont
105.	Tennant, Carl F.	Box 246	Compton
106.	Van Arsdall, Howard L.	749 City Hall	Los Angeles
107.	Van Norman, James H.	1559-6th Ave.	Los Angeles
108.	Waggoner, E. R.	650 Chamber of Commerce Bdg.	Los Angeles
109.	Warburton, Thos.	225 North D St.	Madera
110.	Warren, A. K.	202 Law Bdg.	Los Angeles
111.	Wilson, Carl	Dept. Water & Power	Los Angeles
112.	Wright, E. L.	Water & Sewer Supt.	Orland
113.	Wright, L. E.	City Engineer	Livermore
114.	Wyman, Alfred W.	756 No. Cluster Ave.	Pasadena
115.	Zuckweiler, G. C.	3735 Ray St.	San Diego

Membership Since October 10, 1928

116.	Deming Co., The	133 North Santa Anita Ave.	Pasadena
117.	Jewett, Herbert	727 W. Arden Ave.	Glendale
118.	Mason, Sherman	Engineering & Street Dept.	Inglewood
119.	Clarkson, Jr., Edward H.	925 Venezia Ave.	Venice
120.	Irwin, L. Wesley	1738 Wellesley Drive	Santa Monica
121.	Marx, Chas. D.	College of Civil Engineering	Stanford University
122.	Paterson, Herbert	City Engineer's Office	Long Beach

Constitution and By-Laws of the California Sewage Works Association

CONSTITUTION

ARTICLE I

Name

The name of this association shall be CALIFORNIA SEWAGE WORKS ASSOCIATION.

ARTICLE II

Object

The object of this Association shall be the advancement of the fundamental and practical knowledge concerning the nature, collection, treatment and disposal of sewage and industrial wastes, and the design, construction, operation and management of sewage works in California, through the interchange, between members of the Association and with others, of information, experience and opinion relating thereto.

ARTICLE III

Membership

Membership shall be of one kind only—to be known as members. Any person, or any Board, Commission or Department interested in the objective of this Association, or any person engaged in the sale or manufacture of sewage works equipment, may be a member of the Association. Each membership shall be entitled to one vote.

ARTICLE IV

Officers

The officers of the Association shall be, a President, two Vice-Presidents, designated as First and Second Vice-President, a Secretary-Treasurer, and five Directors. These nine officers shall constitute the Governing Board of the Association.

ARTICLE V

Amendments

Amendments to the Constitution may be made by a two-thirds vote of the members at the annual meeting.

BY-LAWS

ARTICLE I

Members

Section 1. All members of the preliminary organization shall be members of the Association, without election.

Section 2. Application for membership in the Association shall be made in writing to the Secretary-Treasurer and the applicant must be accepted by a majority vote of the Governing Board as a prerequisite to membership.

Section 3. Any member may be expelled from the Association for cause by two-thirds vote of the Governing Board.

Section 4. Any member may retire from membership by giving written notice to that effect to the Secretary-Treasurer.

Section 5. Any member whose dues are in arrears for one year shall be dropped from membership by the Secretary-Treasurer, provided that any member who has been dropped from membership for non-payment of dues may be reinstated by the Governing Board upon payment of all back dues.

ARTICLE II

Dues

Section 1. Annual dues shall be two dollars, payable in advance on October first, to cover the succeeding fiscal year. Dues are delinquent on January 1st following the annual meeting.

Section 2. The fiscal year covers the period between January 1st and December 31st.

Section 3. Of the annual dues, one dollar shall be paid to the Federation of Sewage Works Associations for membership in the Federation and shall entitle the member to a copy of the Federation publications for the fiscal year covered.

Section 4. Any member whose dues are delinquent shall not receive publications of the Association or Federation until such dues are paid. Any member who shall have been reinstated to membership, as provided in Article I, Section 5 of these By-Laws, shall then be entitled to receive such numbers of the Association or Federation publications as may have been withheld on

account of non-payment of dues, provided such publications are still available.

ARTICLE III

Section 1. Officers of the Association shall be elected from members in good standing.

Section 2. The President, First and Second Vice-Presidents and the Secretary-Treasurer shall be elected to serve from the close of one annual meeting until the close of the next annual meeting.

Section 3. Directors shall be elected to serve for a term of five years each, except as follows: At the first annual meeting in 1928 there shall be five Directors elected; one to serve for one year, one for two years, one for three years, one for four years and one for five years, and at each annual meeting subsequent to the annual meeting of 1928 there shall be one director elected to serve for five years. A year shall be taken to mean the time elapsed from the close of one annual meeting until the close of the next annual meeting.

Section 4. No elective officer, excepting the Secretary-Treasurer, shall be permitted to succeed himself in office but any officer shall be eligible for any other office.

Section 5. Vacancies shall be filled by appointment by the Governing Board, appointees to hold office until the next annual meeting of the Association, at which time any unexpired term of office shall be filled at regular election.

Section 6. The President shall have general supervision of the affairs of the Association, subject to the direction of the Governing Board. He shall preside at all meetings of the Association.

Section 7. The Governing Board shall have full control of the affairs of the Association, subject to the acts of the Association in regular meetings. The President shall be Chairman of the Governing Board and preside at all meetings. The Board shall meet at the call of the President and shall hold a meeting just prior to the opening of the annual meeting of the Association. All questions before the Governing Board, except that of expulsion, shall be decided by a majority vote. Five members shall constitute a quorum. The Governing Board shall also vote by letter ballot at the request of the President, which vote shall be conclusive provided a quorum votes.

Section 8. Not less than 30 days after the annual meeting the President shall submit to the Governing Board the names of all committeemen for the ensuing year and the Governing Board shall decide upon their selection prior to appointment.

Section 9. The Secretary-Treasurer shall attend, and shall record the proceedings of, all annual meetings and meetings of the Governing Board. He shall also attend to the collection of all dues and money due the Association and shall prepare all claims against the Association for payment and shall pay the latter upon approval thereof by the President.

Section 10. The officers of this Association shall not incur any liability on behalf of the Association except with the approval of the President and not in excess of the amount actually in the treasury. At the annual meeting, the Secretary-Treasurer shall make a report of the financial condition of the Association.

ARTICLE IV

Meetings

Section 1. There shall be an annual meeting of the Association, the time, place and duration to be determined by the Governing Board not less than three months prior to the meeting.

Section 2. Special meetings may be held at such times and places as may be determined by the Governing Board.

Section 3. Thirty days' notice of all meetings shall be given each member by mail.

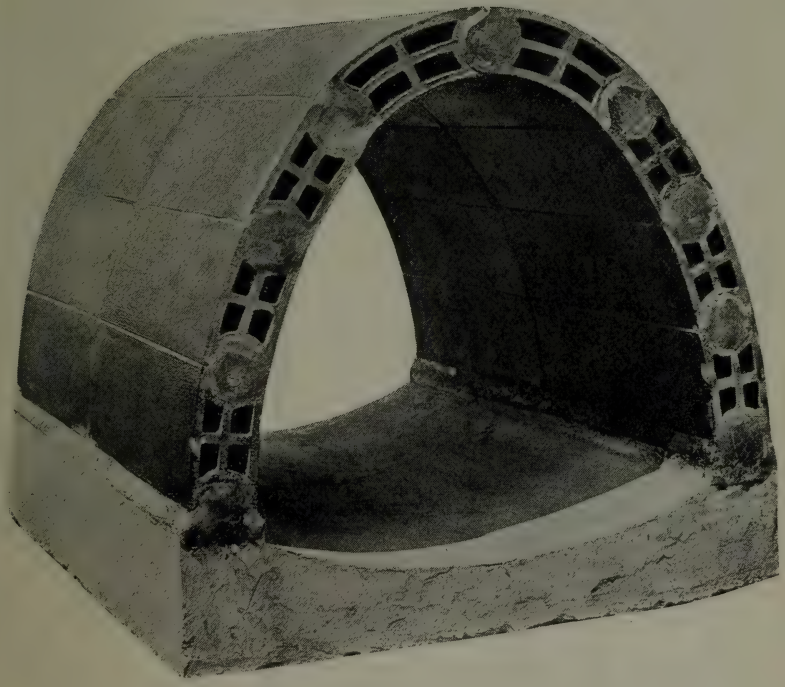
ARTICLE V

Amendments

Amendments to the By-Laws may be made by a two-thirds vote of the members at the annual meeting.

"Best on . . . or Below . . . the Earth"

PACIFIC



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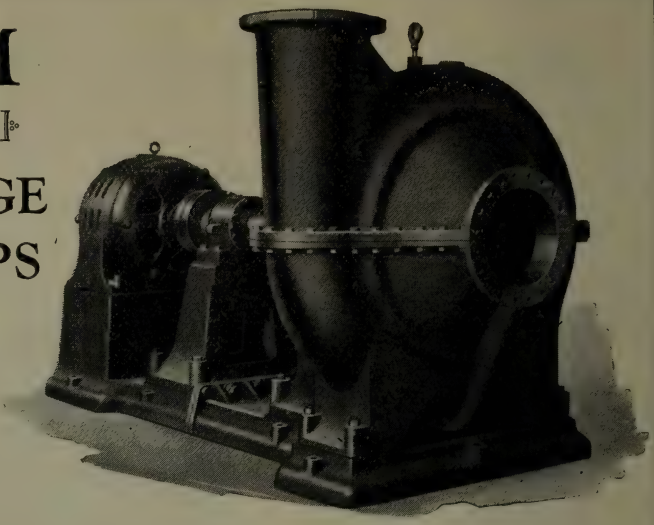

Will pass *any solid* which enters the suction nozzle!

Definite economies in station construction and operation are made possible by these pumps which do not require pre-screening of liquids. No wedging of solids to interrupt operation.

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Santa Monica, Calif. — Garden Grove, Calif.
Santa Barbara, Calif. — Kelso, Washington
Renton, Washington — Portland, Oregon
Sanger Winery, Sanger, Calif.
Longview, Washington — Roslyn, Washington
Sunnyside, Washington
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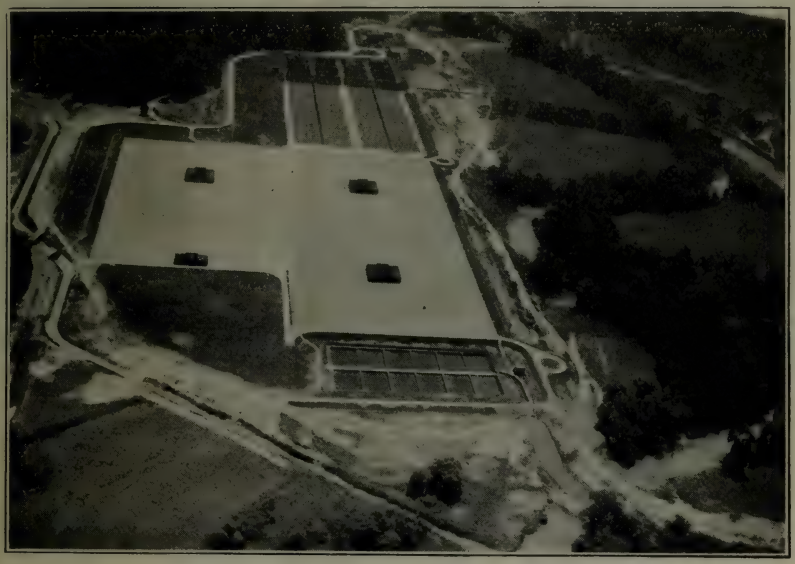

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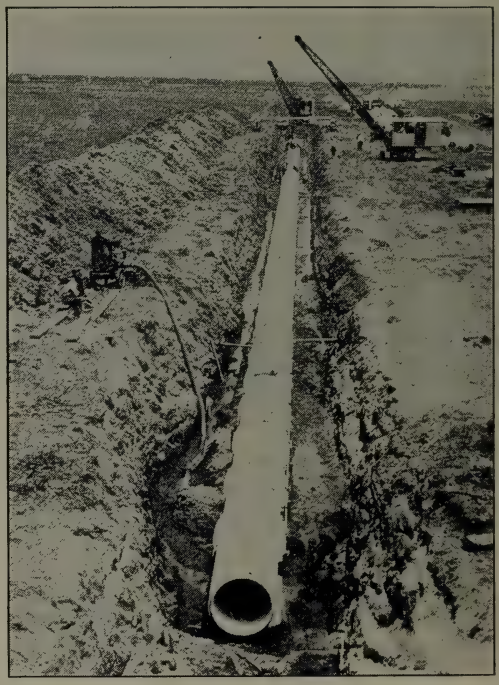

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CALIFORNIA SEWAGE WORKS JOURNAL

VOL. II • 1929 • No. I

Proceedings of the
Spring Conference at Fresno;
Second Annual Convention at Oakland;
Special Article
ana
University of Southern California
Short Course School in
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CALIFORNIA SEWAGE WORKS JOURNAL

Address all communications to the Secretary
Membership and Annual Dues $2.00

This Journal, together with the Journal of the Federation of Sewage Works Associations, free to members. Extra copies, $1.00.

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Printed by
WESTERN CONSTRUCTION NEWS, Inc.
114 Sansome Street, San Francisco, California.

CALIFORNIA SEWAGE WORKS JOURNAL

Published by

CALIFORNIA SEWAGE WORKS ASSOCIATION

VOL. II 1929 No. 1

CONTENTS

Page

Officers and Committees - - - - - - - - - - 4

California Sewage Works Association—Its Organization, Objects, and Progress—Leon B. Reynolds - - - - - - - - - 5

Announcement of 1930 Spring Conference to be held at Sacramento, April 21-22; and Prizes for Best Maintained Sewage Treatment Plant - 8

Program—Spring Conference, Fresno, March 20-21, 1929 - - - 9

Minutes—Spring Conference, Fresno, March 20-21, 1929 - - - 10

Papers Read at Spring Conference, Fresno (*with abstracted discussion*)

Pumping Sewage—Herbert Patterson . - - - - - - 13

Imhoff Tank Operation—L. H. Gadsby - - - - - 21

Sewage Treatment Plant, Lemoore—C. C. Kennedy - - - 26

Experience with Flat Sewer Grades—Andrew M. Jensen and F. J. Rossi - - - - - - - - - - - - 32

Fresno Sewer Farm—Andrew M. Jensen - - - - - 37

Sewage Disposal Practice in Europe—Charles Gilman Hyde - - 42

Program of Second Annual Convention, Oakland, October 7-10, 1929 - 64

Minutes of Second Annual Convention - - - - - - - - 66

Resolutions Adopted at Second Annual Convention - - - - 71

Sewage Treatment Plants Visited, October 7 - - - - - 73

Papers Read at Second Annual Convention, Oakland (*with abstracted discussion*)

Oil Exclusion and Removal—F. A. Batty - - - - - 78

Symposium on Sewage Disposal and Costs

Digestion of Activated Sludge at Pomona—F. H. Froehde - - 82

Separate Industrial Sewers and Chlorination at Tulare—R. M. Berryhill - - - - - - - - - - - - 88

Foaming and High-Rate Land Disposal at Visalia—L. H. Gadsby - 92

High-Rate Land Disposal at Modesto—F. J. Rossi - - - 96

CONTENTS — (*Continued*)

Page

Pumping and Foaming, Imhoff Tanks, Stockton—W. B. Hogan - 100

Gas Burning and Chlorination at San Bernardino—F. S. Currie - 105

Cost Keeping, Los Angeles County Sanitation Districts—A. K. Warren - - - - - - - - - - - - 112

Fly Control at Sewage Treatment Plants—W. B. Herms - - 117

Sewer Grades—A. M. Rawn - - - - - - - - 123

Relative Costs of Sewerage—D. E. Perry - - - - - - - 128

State Supervision of Sewage Disposal in California—C. G. Gillespie 133

Responsibilities and Procedure of Municipalities—B. J. Pardee - 138

Symposium on Sewage Disposal to Salt Water.

Float Surveys and Wrought-Iron Pipe Outfalls at Santa Cruz—C. G. Hyde - - - - - - - - - - - - 141

B. Coli Surveys at Hyperion Outfall Sewer, Los Angeles—W. T. Knowlton - - - - - - - - - - - - 150

Settling Tanks for Bay Outlets, San Diego—F. M. Lockwood - 153

Slough Disposal at San Anselmo—C. C. Kennedy - - - 156

Experimental Work on Outlet Structures for Los Angeles County—A. M. Rawn - - - - - - - - - 159

Concrete Pipe Outfall Sewer and Pumping at San Rafael—H. K. Brainerd - - - - - - - - - - - 166

Bay Disposal and Chlorination at Newport Beach—R. L. Patterson 172

Sewage Disposal in California—Leon B. Reynolds - - - 177

Abstracts of Papers Read at Sanitary Engineering Section, School of Citizenship and Public Administration, Short Course, University of Southern California, June 17-22, 1929 - - - - - - 181

How to Write an Article for a Technical Periodical—Philip Schuyler - 198

Antimony Method for Sulphide Determination—A. J. Salle and E. A. Reinke - - - - - - - - - - - - 208

What the East is Doing New in Sewage Disposal—R. F. Goudey - - 210

Roster of Members - - - - - - - - - - - - 226

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Addresses will be found in List of Members on Page 226.

California Sewage Works Journal

The California Sewage Works Journal is not responsible, as a body, for the supposed facts and opinions advanced in any of the papers, discussions, or articles published in its Journal. Discussion of all papers is invited.

VOL. II. 1929 No. 1

California Sewage Works Association

Its Organization, Objects, and Progress

The object of this Association shall be the advancement of the fundamental and practical knowledge concerning the nature, collection, treatment and disposal of sewage and industrial wastes, and the design, construction, operation and management of sewage works in California, through the interchange, between members of the Association and with others, of information, experience, and opinion relating thereto.

—Article III, Constitution C.S.W.A.

By LEON B. REYNOLDS, 1929 President*

As president of the California Sewage Works Association I wish to thank Commissioner Parker for his gracious welcome. The association is glad to come to Oakland for its second annual meeting. Workers interested in sewerage and sewage disposal throughout the United States have been meeting in groups in connection with other kinds of associations for some years. Two years ago last March temporary committees were appointed and two years ago last July a committee of one hundred, representing all sections of the country, was appointed to study the situation. The report of this committee was that local associations should be encouraged and strengthened and joined in a National

*This paper was read as the response of the president at the Second Annual Convention at Oakland. See page 66.

Federation of Sewage Works Associations. This federation was formed and its board of control held its first meeting in October, 1928, at which time the constitution and by-laws were adopted. The constitution states the objects of the federation to be two, as follows: first, "the advancement of fundamental and practical knowledge concerning the nature, collection, treatment, and disposal of sewage and industrial wastes, and the design, construction, operation, and management of sewage works, through the correlation and strengthening of local, state, and district sewage works associations, and the publication of a journal designed to meet the needs of persons active or interested in these fields of endeavor"; second, "the promotion and encouragement of improved waterways sanitation, through the same measures".

In June, 1928 a group of fifty-one men interested in sanitation met to consider the propriety of organizing an association in California; it was voted unanimously so to do, an organizing committee was selected, and it was decided to hold the first annual meeting in conjunction with the League of California Municipalities one year ago this month. At that time our constitution was adopted, which reiterated as the object of our association the advancement of knowledge, in this case, "through interchange between members of the association and others of information, experience, and opinions".

This is the second annual meeting of the association. At the end of our first annual meeting one year ago we had 115 members, at the end of our spring meeting last March we had 181 members, and now our roster includes 207 names, the largest association in the federation. There are now at least fourteen associations joined together in the federation for mutual help, with several others under organization, and their total membership probably approximates one thousand.

I had the opportunity two months ago to attend the first annual inspection meeting of the New York State Sewage Works Association in Rochester, and this association now has a membership of 175, so that they may soon be passing us for the lead in numbers. S. E. Coburn of Boston, the president of the New England Association, was also present and we were called upon to tell about the work and progress of our associations.

It is no longer necessary to apologize for holding a public meeting of a sewage works association—they seem to be becoming the style all over the country.

Even such a self-respecting city as Oakland welcomes us and sends its commissioner of streets to express its welcome verbally. Oakland three years ago discovered the inadequacy of its sewer system and its sewage disposal methods and appointed a commission, all of whom are now members of this association, to study its problems. It was reported that, notwithstanding the apparently unlimited dilution, local pollution already existed along the water front, and the development of the harbor and the industrial growth of the city would be hampered, if not halted, if these nuisances were allowed to develop into a major nuisance. Hence even our cities similarly located on or near tidewater have problems of sewage disposal difficult to solve.

Many of our treatment plants in this state have been neglected almost, if not quite, to the point of abandonment; many of them have been unintelligently, even if conscientiously, operated; some communities have hesitated to construct, or excused themselves from constructing, disposal plants, due to the difficult problems presented by industrial wastes intermingled with the domestic wastes.

California is recognized as a great vacation land, attracting increasing numbers of tourists from beyond its borders; many believe that our state is also on the eve of a great industrial development. If we are to maintain the attractiveness and safety of our state, and if we are to provide properly for industrial expansion, we need more trained sanitary engineers, more scientific design of plants, more intelligent supervision of plant operation, more laboratory control of processes, more plant beautification, better ways of financing operation and maintenance; yes, and more research in methods of treatment. We believe that this association can be helpful in accomplishing these desired results and this is the reason for its existence.

Spring Conference to be Held at Sacramento, April 21 and 22, 1930

Prizes for Best Maintained Sewage Treatment Plant

Spring Conference

The board of directors at first selected San Luis Obispo as the best place to hold the spring conference in April. Soon thereafter, the American Society of Civil Engineers announced April 23 to 26 as the date of the national spring meeting at Sacramento. As many of the members of the C.S.W.A. will also wish to attend this meeting, it was suggested that the spring conference be held in conjunction with the sanitary section of the A.S.C.E. But, as the C.S.W.A. is primarily for sewage works operators and practical discussions, the directors finally decided to hold the spring conference in Sacramento, April 21 and 22, immediately preceding the A.S.C.E. convention.

There will be, as usual, papers and discussions on several subjects, but the principal feature of the conference will be a trip of inspection to the sewage treatment plants at Davis Farm, Lodi, and Chico, with detailed lectures on the design and operation of each —in other words, a 'Short Course' school on sewage treatment.

Prizes

The board of directors has decided to award a yearly prize for the best maintained and operated sewage treatment plant. The prize will consist of a bronze plaque, on which each year will be engraved the name of the town or district and operator in charge. In addition to this, the operator will receive a cash prize of $25. These prizes will be donated by the manufacturer-members of the association.

Program, Spring Conference

Fresno, California, March 20-21, 1929

Wednesday, March 20

In Auditorium of San Joaquin Light & Power Co. Building.

10.00 a.m.—

Address of Welcome, by A. E. Sunderland, Mayor, City of Fresno.

Response, by Leon B. Reynolds, president.

'Pumping Sewage', by Herbert Paterson, assistant city engineer, Long Beach. Discussion by Thos. Warburton, city councilman, Madera, and by others.

'Imhoff Tank Operation', by L. H. Gadsby, city engineer, Visalia.

Discussion by W. B. McWharter, superintendent of sewers, Exeter, and by others.

12:00 a.m.—Luncheon.

2:00 p.m.—

'Sewage Treatment Plant, Lemoore', by C. C. Kennedy, consulting engineer, San Francisco.

'Experience with Flat Sewer Grades', by Andrew M. Jensen, commissioner of public works, Fresno; F. J. Rossi, city engineer, Modesto; and discussion.

'Fresno Sewer Farm', by Andrew M. Jensen, commissioner of public works; followed by

4:00 p.m.—Inspection of Fresno Sewer Farm.

6:30 p.m.—

Joint dinner with San Joaquin Valley Section of League of California Municipalities, in Ballroom, Hotel Californian. Entertainment.

8:00 p.m.—

'Sewage Disposal Practice in Europe', illustrated, by Charles Gilman Hyde, professor of sanitary and hydraulic engineering, University of California.

Thursday, March 21

Automobile Inspection trip of Sewage Treatment and Disposal Plants.

Lemoore—New plant consisting of pumps, Simplex aerators, Hardinge clarifier, sprinkling filter, and sludge bed.

Tulare—Link-Belt clarifiers, separate sludge digestion (activated sludge tank not in use), and sewer farm.

12:15 p.m.—

Luncheon at Visalia as guests of City Council.

Visalia—Four large Imhoff tanks and sewer farm.

Reedley—Imhoff tank, sprinkling filter, final settling tank, and natural sand beds.

Minutes of Spring Conference

Held in Auditorium, San Joaquin Light & Power Co. Bdg.

Fresno, March 20, 1929

Meeting called to order at 10 a.m. by L. B. Reynolds, president.

A. E. Sunderland, mayor of Fresno, delivered address of welcome, and President Reynolds responded.

Andrew M. Jensen, commissioner of public works, Fresno, and in charge of local arrangements for the conference, made several announcements regarding luncheon, dinner, and registration.

Herbert Paterson, of Long Beach, read a paper on 'Pumping Sewage', which was discussed by Warburton, Perry, Schuyler, Batty, Gray, Rogers, Hommon, Barzellotti, and Hammerly.

L. H. Gadsby, of Visalia, read a paper on 'Imhoff Tank Operation', which was discussed by McWharter, Hall, West, Froehde, and Gillespie.

Meeting adjourned promptly at noon.

Members and guests joined with the Engineers Club of Fresno for a luncheon at the Fresno Hotel. Entertainment was provided, and an interesting talk on Europe given by Charles Gilman Hyde, professor of sanitary and hydraulic engineering, University of California.

Afternoon session opened at 2 p.m.

The secretary's report showed 160 members on arriving at Fresno and 8 new members, giving a total of 168. Of the 160 classified, 38% were city, county, or state engineers; 13.7% administrators; 16.2% consulting engineers; 14.4% commercial men; 10% operators; 3.7% laboratory or research workers; and 3.7% miscellaneous.

The treasurer's books showed $381.60 received and $261.38 expended, leaving a balance of $120.22.

B. J. Pardee, chairman, reported for the program committee.

C. C. Kennedy, chairman, standard report forms committee, reported progress, and stated that a report would be presented at the annual meeting in October.

W. T. Knowlton, chairman, sewer maintenance committee, announced that there was objection to Senate Bill No. 651, and that it would not pass in its present

form. The Committee will present a new bill at the October Meeting.

A. K. Warren brought up the proposed 'State-Aid Sewage Research' before the state legislature, known as Senate Bill No. 652. C. G. Gillespie outlined the progress of the bill, which provides $65,000 and has reached the ways and means committee. The state department of finance indicated that $40,000 was the most that the state fund could allow, which means that the start of the work must be delayed almost a year and that at the end of the biennium the appropriation must be stepped up to $65,000. C. C. Kennedy added that after several trips to Sacramento by those interested in the work, the department of finance has been convinced that the work is a state function and now it is merely a matter of determining the amount of money to be provided.

Moved by W. T. Knowlton, seconded, and unanimously carried, that the California Sewage Works Association endorse and request the legislature to approve Senate Bill No. 652.

President Reynolds announced that lists of the cities which endorsed the bill were available, and all but perhaps half a dozen of the cities of 10,000 population or over had endorsed it.

Philip Schuyler suggested that the members send letters or telegrams to their representatives in the legislature urging the passage of Senate Bill No. 652 and that the minimum amount be $65,000.

As chairman of the membership committee, Schuyler outlined the work which the association could do and urged all who had not yet joined to do so.

As chairman of the editorial committee, E. A. Reinke asked that any suggestions or criticisms regarding the Journal be sent to him; or C. G. Gillespie or President Reynolds, the other two members.

President Reynolds announced the appointment of a special committee to work in cooperation with the School of Citizenship and Business Administration of the University of Southern California. The members are A. M. Rawn, chairman, J. C. Albers, Carl Wilson, and H. A. Jewett.

Rawn reported for the committee that meetings had been held with Emery E. Olson, director of public administration of the school, and a tentative program outlined. It consists of a course extending through the second week in June, with two sessions daily, in the afternoon and evening. In connection therewith, there is a course in municipal chemistry and testing, and the same fee will cover both. The course will consist of

a lecture by some prominent authority and the discussion of two papers each for fifteen minutes, consuming the hour and a half. The papers will be published, probably in a loose leaf form with a binder furnished to keep a permanent record. (An abstract of these papers appears elsewhere in this journal.)

Harold F. Gray moved, and it was seconded and carried, that a committee be appointed to study and report on the distribution of cost of waste disposal to the industry and the municipality.

President Reynolds asked for a vote on who would like to have a question box with questions handed in before the meeting, and qualified persons found to answer them. The majority favored the suggestion.

C. C. Kennedy read a paper on the 'Lemoore Sewage Disposal Plant', which was discussed by W. C. Roberts and F. V. Hammerly.

A. M. Jensen led a discussion on 'Flat Sewer Grades', followed by Rossi, Berryhill, Barzellotti, Perry, Knowlton, and Blood.

A. M. Jensen described the Fresno sewer farm, which was visited after the meeting adjourned.

Attendance 122. Membership at close of session 176.

An evening session was held jointly with the South San Joaquin Valley Section of the League of California Municipalities at the Hotel Californian, consisting of a dinner, entertainment, and an interesting and instructive illustrated talk by Charles Gilman Hyde on 'Sewage Disposal Practice in Europe'.

On Thursday morning the members met at the city hall in Fresno and proceeded by caravan to the sewage disposal plants at Lemoore, Tulare, Visalia, and Reedley. Luncheon was furnished at Visalia through the courtesy of the city trustees. The party disbanded at Reedley at 4:30 p.m.

Following the meeting letters of appreciation were sent to B. J. Pardee, chairman program committee; A. M. Jensen, in charge of local arrangements; San Joaquin Light & Power Co. for use of auditorium; and the city trustees of Visalia for luncheon furnished on day of trip.

Respectfully submitted,
E. A. Reinke, Secretary-Treasurer.

Pumping Sewage

By Herbert Patterson*

Up to a few years ago, little attention had been paid to the question of pumping sewage.

The average sewage pumping station consisted of a tank lined with wood or brick, with a platform on which was mounted any old kind of centrifugal pump, the whole enclosed in a tin building. The station was generally built as far as possible from a human habitation, and no attempt was made at cleanliness or odor control. The whole installation was a nuisance and an offense to the community which it was supposed to serve.

Of late years, however, great strides have been made in correcting these conditions, and an up-to-date sewage pumping station is no longer considered objectionable or a detriment to the neighborhood.

The city of Long Beach has been a fruitful field for the development of high-standard sewage pumping stations. We are today operating 14 pumping stations and expect to add several more as the size of the city grows. As the city is entirely residential, and as many of the pumping stations are in congested areas, we have had to overcome the three main objections to their installation, namely: odor, noise, and unsightliness; and evolve a type of station conforming to the prevailing style of architecture, and which cannot be recognized for what it is by any other means than entering the building itself. This we have been successful in accomplishing, and we can now build a sewage pumping station next door to an apartment house or private dwelling, without protest either before construction, or later during its operation.

Design—There are so many items entering into the design and operation of a successful sewage pumping station that it is only possible in a short paper to touch on them.

To begin with, odor control depends largely in dealing with the sewage while it is still fresh. Therefore,

*Assistant City Engineer, Long Beach, California.

the district to be served should be no larger than will allow the sewage from the most distant point to reach the station within at least three-quarters of an hour.

The sewage should not be kept in the station longer than necessary and should be pumped out every 10 or 15 minutes.

The force main should be large enough to avoid an undue friction head, but not so large that sewage will be stored there for an unreasonable length of time.

The wet well, or storage reservoir, should be vented with at least an 8-in. pipe to the nearest manhole.

Henderson Avenue Pump Station In Residential Section, Long Beach

Venting with a stack causes disagreeable odors in damp or foggy weather.

The pump room should be made large enough to accommodate a steel stairway and still leave 2-ft. clearance beyond any moving parts of the machinery, as required by the State Accident Commission. All moving parts must be equipped with safety guards. The most economical and satisfactory form of station I have found, is a circular pit with a vertical division wall near the center, providing a wet well and a dry well for a pump room. Horizontal centrifugal pumps direct connected to electrical motors are placed at the bottom of the dry well, and the switch boards are placed on an intermediate floor 10 or 12 ft. higher. Steel stairways with handrails are provided for the dry well, and a galvanized iron ladder in the wet well. The whole pit is covered with a concrete slab about

surface level, and a brick and stucco bungalow style building erected thereon. This building houses a lavatory and toilet, and the entrance stairway to the dry well. There is also a manhole to the wet well covered with a metal plate. The wet well should have sufficient capacity below the inflow sewers to provide at least 20 minutes storage; this being the time allowed for a possible interruption of electric service. The wet well should be lined with vitrified clay liners to prevent disintegration of the concrete by sewer gases; these liners being made with ground edges to insure a close fit, and in placing, the edges dipped in hot asphalt. No cement is used in the joints. The walls of the dry well, and the floor and walls of the building, should be oil painted, as this has been found to help considerably in the elimination of odors.

The construction of these circular pits presents no special difficulty. The usual practice is to sink an open excavation until ground water is reached. Forms are then placed providing a recess at the bottom for the floor slab. Concrete is poured to the surface, and after curing and stripping, the pit is sunk to the required level as a caisson.

A perforated box, with a 12-in. flanged nipple on top, is placed below the floor-slab level to act as a sump for the ground water while the slab is being poured; the 12-in. nipple being long enough to extend three inches above the finished floor. The suction of the sinking pump passes through this nipple and the ground water is kept down during the setting of steel and the pouring of the slab. After the slab has set for 24 hours, pumping is stopped and the water allowed to rise in the pit during the curing period; after which the water is pumped out and the nipple closed with a blind flange.

By this method and a rich mix of concrete (namely 1:1½:3) a dry pit is assured, no dampness appearing even on the walls.

Pumping Equipment—We have experimented with many types of pumps, the chief disadvantages of each being:

Submerged centrifugal. In case of choke up or repairs, the whole unit must be dismantled in order to raise the pump.

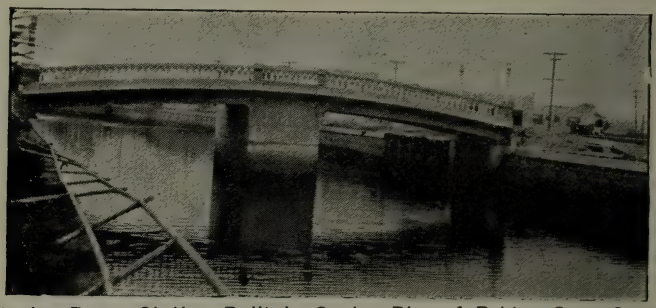
Horizontal centrifugals set above the pit, with ver-

tical suctions and foot-valves. Difficulty of keeping foot-valves clean; constant loss of priming.

Vertical centrifugals in dry well with motors on motor floor. Difficulty in getting under pumps for cleaning out; vibration noises from vertical shafts.

Pneumatic ejectors. Costly installation; necessity of running compressors continuously; difficulty of keeping check valves tight; odor from exhaust; noise from unloaders.

The most satisfactory type of pump has proved to be the horizontal centrifugal with two-port impeller direct connected to motor. Placed at the bottom of



Naples Pump Station Built in Center Pier of Bridge Over Canal in Residential Section, Long Beach

the dry well, they are always easily accessible, the location is comfortable and clean to work in, and the nuisance from odor and noise is reduced to a minimum. These pumps are always installed in duplicate and are alternated weekly in operation.

Efficiency and Testing of Pumps—The efficiency of two-port impeller pumps increases with the size, the range being between 57% for a 4-in. pump and 77% for a 30-in. pump. The advantage, however, of a high efficiency is almost entirely lost by the constant stopping and starting in this service. Our specifications read substantially as follows:

'Pump shall deliver ..... gallons per minute at an average head of ..... feet. It shall operate at near its maximum efficiency at this head and the pump and motor shall have an overall efficiency of not less than 50%. The pump and motor shall operate without vibration or overloading between a maximum head of ..... feet and a minimum of ..... feet.'

A performance test of the pump must be made by the manufacturer, and a certified copy of its characteristic curves supplied to the city engineer. In test-

ing the pump, the wet well (the capacity of which is known) is filled, vacuum and pressure gauges are attached to the suction and discharge lines close to the pump, and an ammeter connected to the motor. The water is then lowered a given number of feet and the head, discharge, and power consumption compared with the performance curve. The variations in head are obtained by means of a gate valve on the discharge line. In this way we get a fair idea of whether the pump comes up to our specifications.

Maintenance—In such a vital matter as the pumping of sewage, it is essential that there should be no interruption in the service. However good the pumps, discarded underwear, towels, etc., will choke them up. The automatic electrical equipment also is sensitive and occasionally burns out. Lubrication and packing have to be attended to.

For the above reasons we maintain a close inspection over all pumping stations. They are visited by maintenance men every four hours throughout the twenty-four. This necessitates a crew of two men on each eight-hour shift; one relief man to take up the seventh shift for each of the others; one repair man, and a foreman.

Cleanliness is insisted upon. Each station is provided with lavatories, soap, towels, and first aid equipment. Once a month the walls and floors of the wet wells are scoured with brooms and washed down with fire hose. A desk with a log book is provided in which the operator enters the time of his visit and any work or repairs he makes.

The cost of maintaining the 14 stations during the last fiscal year, including wages, repair parts, electrical energy, and supplies, was $24,786 or $1770 per station per year, or $147.50 per month. For 24 hours, uninterrupted service throughout the year, I do not consider this sum excessive.

Conclusion—In order to provide efficient pumping stations there are five indispensable requisites:

Dry pits.

Pumps with large impeller openings and open suctions.

Removal of the sewage at short intervals.

Ample ventilation.

Rigid inspection.

In this 'sketchy' paper I may have omitted many points which would interest you, but I shall be glad to reply to any questions personally or by mail; or better still, to welcome you to Long Beach and accompany you on a personal inspection of our system.

DISCUSSION

Thos. Warburton gave the experience of Madera with pumps handling raw sewage ahead of an Imhoff

Magnolia Avenue Sewage Pump Station, Constructed Under Garden Adjoining Apartment House, Long Beach

tank. In 1922, when the plant was built, two 5-hp. vertical, open-runner Byron Jackson pumps were installed. These caused continual grief to the operator, who had to remove rags and other materials from below the runners at least once a week. In 1923, a 15-hp. vertical closed-runner Byron Jackson pump, with two ports, was installed, which has run for six years with no trouble and only one change of bearings. He thought Mr. Paterson's remarks about horizontal pumps good, and believed the horizontal, two-port, closed-runner impeller type satisfactory for sewage works. He also stressed the importance of having pumps in a dry well. The average cost for power at Madera is $60 per month or $720 per year. They have no data on sewage flow, so cannot give cost per million gallons. In reply to a question by Don E. Perry,

of San Anselmo, Mr. Warburton stated that all sewage passed through 1¾-in. bar screens before reaching the pumps.

Mr. Perry reported that the Marin Sanitary District No. 1 operates three vertical pumps, and that trouble was experienced formerly with rags at weekly to monthly intervals. Strainers were taken off the pumps and new strainers put in where the outfall sewer enters the pump sump, which practically eliminated the trouble. Another 'stunt' used to relieve clogging, was to reverse the wiring on the motors and run the pump backward for about five minutes. The pumps are in a wet well and cleaning them is a disagreeable and dirty piece of work, it being necessary for the men to come out of the pit at about ten-minute intervals to get fresh air.

In reply to a question by Philip Schuyler, Mr. Paterson stated that data on costs were not kept as close as he would like, but that both the city and county of Los Angeles were keeping records on universal forms which will give all the information.

In reply to a question by F. A. Batty, of Los Angeles, concerning disintegration of asphalt joints between tile in pumping pits, Mr. Paterson stated that the joint was so thin, it would take careful inspection to find any disintegration, and so far he had noticed none. Long Beach sewage is two hours old at the pump sumps. Mr. Batty stated that Los Angeles sewage twelve hours old gave a good deal of trouble.

Harold F. Gray, of Berkeley, discussed the general problem of pumping, and laid particular stress on the desirability of planning streets and grades in a manner which provides adequate grades for sewers. In Oakland he reported two or three areas in which street grades are so low and flat that it is no longer possible to carry accumulating sewage from certain large areas into a bay outfall, without an expensive outfall sewer or resorting to pumping.

K. Rogers, of Montezuma School, reported success in pumping small quantities of activated sludge with a 1¼-in. Viking pump.

H. B. Hommon, engineer, U. S. Public Health Service, reported trouble with bearings getting out of line, the shaft developing a parabolic motion and wearing on one side only (Yosemite Valley). No apparent

clogging has taken place between the impeller and casing, the trouble apparently being due to the unbalancing of the shaft itself.

Carl Hoskinson, of Sacramento, gave the experience at Sacramento where solids from canneries cause trouble, and asked what arrangement Long Beach has made to take care of them. Mr. Paterson replied that no cannery solids were allowed in the sewer, the canneries having tried to dump the whole wastes from their plants but the city could not take care of it. He also added that wear on shafts was often due to unbalanced impellers, and that vibration could be overcome by re-turning and re-balancing them.

L. F. Barzelotti, of Lodi, reported no trouble with Byron Jackson vertical pumps handling fine-screened sewage.

Fred Hammerly, of Water Works Supply Co., brought up several points from the salesman's angle. Pump impellers are balanced at the factory and shipped balanced. How long does it take and why do they become unbalanced? Vertical pumps give more trouble than horizontal because of line shaft trouble. In 1918 his company put in a Byron Jackson open-runner pump for handling screenings, guaranteed by the pump company. The pumps would not operate without clogging within about two minutes, so the Byron Jackson company then developed their two-port closed runner.

Later, as agents for the American Pump Co., a single port, closed-runner pump has been handled. For small sizes and low speeds it gives indifferent operation. The impellers get out of balance and particularly in vertical pumps the line shaft causes trouble.

Mr. Hammerly added that life of pumps in sewage work is shorter than when used to pump water, on account of the changing specific gravity of sewage. The American Pump Co. has done most of the work in the East, and has developed several different types of pumps, the most satisfactory being one with multiple ports and large size. Size has a lot to do with troubles, the bigger the pump the less the trouble; but with small sewerage works it is important to have small pumps that will give good results.

Imhoff Tank Operation

By L. H. Gadsby*

The city of Visalia uses an Imhoff tank for treatment of its sewage. The character of the sewage handled is probably not much different from that of other small cities, being largely domestic with the addition of the small industries that nearly every town possesses, such as laundries and dry cleaning works, garages, automobile wash racks, and a creamery. Visalia does have one seasonal industry that complicates its disposal problem, and this consists of two good-sized peach canneries which operate during July, August, and into September. Little storm drainage goes into the sanitary sewer system.

It is worthwhile to go back into local history a bit and note the fact that in 1914 the city had almost determined to install some Cameron-type septic tanks. Fortunately, Charles Gilman Hyde, of Berkeley, was secured to make an investigation, and his report recommended strongly that the Imhoff type tanks should be used instead.

In 1921 a bond issue of $100,000 was passed to provide for a sewage treatment plant and certain needed sewer additions. Following this, I made something of a study of the problem, visiting as opportunity offered many of the then existing treatment plants throughout the state. Although I saw some Imhoff plants that were not operating satisfactorily, I came to the conclusion that a plant of this type would operate quite well at Visalia if given some care and attention; and I had observed that the plants that were not doing well were in most cases very much neglected. I think I learned at this time the valuable lesson that any type of plant for treating sewage must have some care.

With the aid of many wise and practical suggestions from C. G. Gillespie and E. A. Reinke, of the State Bureau of Sanitary Engineering, I designed the structure, a permit was granted, and the unit constructed in 1923. The Imhoff tank feature of the plant

*City Engineer, Visalia.

follows quite closely the conventional pattern, but the unit as a whole has certain unique and perhaps to some degree questionable differences. The tank is only 20 ft. deep, which is quite shallow for an Imhoff tank; it has no piping installed for stirring up the sludge by water under pressure; the gas vents have the exceptional width of 4 ft.; and, most important, there is an auxiliary chamber 32 by 65 ft. in plan, which can be filled to a depth of 11 ft. with sludge run from the sludge compartments of the Imhoff tanks. It was thought wise to install this separate sludge digestion unit because of the great quantity of peach cannery waste which we have to handle within a comparatively short time. Also, the tank was designed so that the sewage flow could be reversed, but

Members of California Sewage Works Association Inspecting Imhoff Sewage Treatment Plant at Visalia

this feature was eliminated after a while, as it was found that little trouble was experienced from sludge collecting at one end, the length of the settling chamber being only 32 feet.

A small sludge-drying bed was constructed, and the sludge is run out by gravity. The proposition of drying the sludge on land was regarded as somewhat experimental, but it has worked well under our conditions of soil and climate.

A grating or rack was installed in the influent channel, but no grit chamber was built. While this rack is perhaps not essential, it does pick up a lot of large rags, sticks, and large chunks of grease which would be something of a nuisance in the tank, although not particularly harmful. Perhaps the most important use of this rack is the fact that material collects on it in sufficient quantity that the flow of sewage would be impeded in a day or two. Therefore we are compelled

to rake it clear occasionally, and we cannot allow ourselves to neglect the tank entirely.

When put into operation, the tank operated without any undue trouble from the start. We had, of course, read about the foaming troubles often experienced with Imhoff tanks, and had seen some examples of it. We were, therefore, somewhat apprehensive lest our tank should do something of this nature, and possibly compel us to build up our freeboard with wooden bulkheads. However, we have had little in the nature of 'foaming', and it is probable that most of it has been largely due to oil skimmed off the influent channel and thrown over into the nearest gas vent. We follow the practice of cleaning out the accumulation of scum in the gas vents about once a year, piling all this material off to the side and burning it after it has partly dried. At this writing we have just completed the operation of cleaning out the gas vents. This material is not particularly odorous, and will presently burn to a small residue of ash.

Drying sludge under our conditions can be a little slow during the winter months, especially if we have frequent rains; therefore we discharge a less depth of sludge during this season. As spring and the warmer weather come on, we begin to increase the discharge of sludge, clearing the drying bed and immediately discharging more sludge, in order to get the tanks in condition by the beginning of the cannery season to take the heavy overload. It is, of course, well known that an Imhoff tank will stand considerable overload, and we certainly use this feature of the tank during the canning season. The normal capacity of our plant is 500,000 gal. per day, but we have occasional days when the canneries run full blast and we find our sewage flow amounts to 2,000,000 gal. in 24 hours.

We have so far not made use of the separate sludge digestion feature of our plant, although during the season of 1928 we would have had to use it if the canning season had lasted much longer. By using care in the operation of the plant, getting the sludge compartments pretty well lowered prior to the beginning of the cannery season, and by considerable diligence during this peak load, we have been able to get along fairly well with our plant. We estimate that the actual labor cost to the city for operating this plant is close

to $500 a year, made up of the wages of one man working every day at the plant during the 60 days or so of the peak season, and the periodical work done during the remainder of the year.

The effluent of the plant is used for irrigation on the 160-acre farm owned and operated by the city. The effluent is used as it comes from the tank, as no filter is installed. It is of interest to note that the income from sales of farm produce during the fiscal year 1927-28 was $5732, while the cost of operating the farm and the disposal plant was $4700.

While this shows a small margin of profit, only about 120 acres are now in shape to be irrigated by the sewage, and the city each year does some more grading and leveling to put more of the land under irrigation, and also adds steadily to the permanent improvements of the farm in the line of buildings, fences, and equipment.

Discussion

W. B. McWharter of Exeter reported experiences with two tanks. He considers foaming troubles due to letting out too much sludge. The letting out of sludge is a very particular job. If gas vent areas are not broken up, the scum gets so stiff you can walk on it. It should be well mixed to allow some of it to settle. On three different occasions he has withdrawn too much sludge and each time the tank has foamed and given off odors.

H. C. Hall (city engineer of Turlock) inquired what happened to bacteria in the tank when caustic soda and peach waste entered. Mr. Gadsby replied that at Visalia the tank was four miles from town and, although the sewage was tinged reddish, he had never observed that it varied the tank a great deal. Sludge is gained fast in peach season. Peach fuzz will not sink. It forms a nice thick blanket on the flowing-through chamber in one day's time. When sprinkled with water it disappears for a few minutes and bobs up again. It is skimmed to gas vents daily, where it seems to decompose quickly.

Fred A. West (engineer in charge South treatment plant of Stockton) reported many difficulties which are being gradually overcome. One of the worst is at canneries handling spinach. Formerly, removable screens were used at the plants, but now permanent screens to keep all large pieces out are installed. The

tank is small, but carrying the sludge level high and drawing off at regular intervals helps to control foaming.

F. C. Froehde (city engineer of Pomona) asked if any cities charge extra for handling industrial waste and if the city is entirely responsible for all trade wastes dumped into the sewer system. He thinks not. During cannery season at Pomona the Imhoff tank and activated sludge plant are by-passed by that part of the system carrying tomato waste, and for 2½ months this material runs raw to the sewer farm. Peach wastes are by-passed and stored for use on the farm. The 100-acre city-owned farm is leased for $1500 per year.

Sewage Treatment Plant, Lemoore

By C. C. KENNEDY*

This paper presents a brief description of the sewage treatment at Lemoore, Kings county, California, 30 miles south of Fresno, preparatory for your visit tomorrow.

The plant, completed in October, 1928, but closed down at intervals, due to mechanical difficulties, since that time has been operating continuously for about three weeks.

Lemoore has a present estimated population of 1750, and is situated in the Tulare Lake basin. The topography is practically level, so that low grades and sluggish flow characterizes the collecting system.

The sewage is a combination of domestic sewage and creamery waste, the effective treatment of which is obviously a difficult problem. Suspended solids average 170 p.p.m., while the B.O.D. (biochemical oxygen demand) varies from 165 to 1000 p.p.m., most samples containing milk waste being between 600 and 700 p.p.m. This flow is contributed by two large creameries, in addition to the domestic sewage, and averages 310,000 gal. per day.

The earlier plant consisted of a closed box-type septic tank, built within the corporate limits of the city, followed by a pumping plant and pressure line to the disposal site, 6500 ft. southerly. This site was really only a point of discharge from which the sewage flowed in an open ditch to lands below, where it was permitted to pond and was used intermittently for irrigation. The odor from the pumping plant, which was immediately opposite the grammar school, was noticeable for a distance of 1000 ft., while the odors along the ditch were strong for a distance of two miles below the plant. Flies, breeding in the ditch, caused the closing down of at least two dairies below the plant.

Realizing the difficulty of the problem, an experimental investigation was started in May, 1927. Based

*Consulting Engineer, San Francisco, and designer of Lemoore plant.

on the available experimental data, treatment by activated sludge aeration, filtered through a lath filter and a combination of both, was determined upon.

The activated sludge unit consisted of a small Simplex aerator, with a runner 2 ft. diam. at the top, mounted in a tank, representing the frustrum of a four-sided pyramid, 15 in. square at the bottom, 8.5 ft. square at the top, and 4.5 ft. deep. In order to secure comparative quantitative results, the aerator was run at such a speed as to give the same peripheral velocity as a full size Simplex unit operated at 60 rev. per min. This gave a turnover of 45 gal. per min. in the tank of 1000 gal. capacity.

The filter was built of lath, laid checkerboard fashion, 8 ft. long, 4 ft. wide, and 4 ft. deep, with a wood floor sloping to a collecting trough at one end. It was dosed by means of a tipping can arrangement, discharging into two distributing pipes.

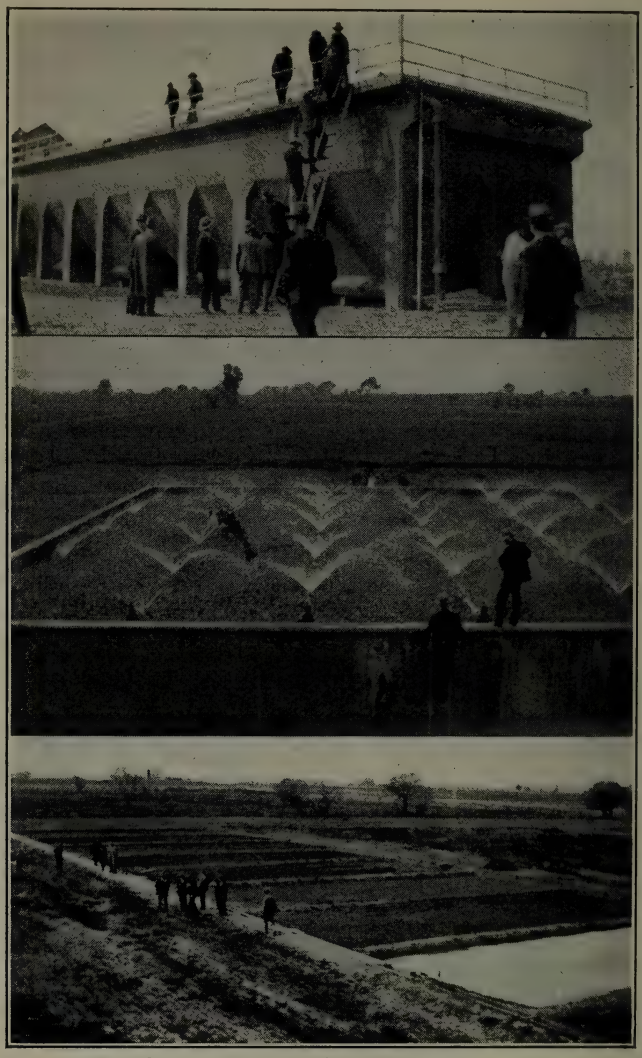
The plant was first set up near one of the creameries and operated on straight creamery waste. After six weeks in this location, it was demonstrated that a clear, odorless effluent with 5-day stability could be produced. The plant was then moved to the existing septic tank site, and there operated for 60 days on the mixed domestic and creamery sewage to obtain quantitative results for use in design. Various periods of aeration with varying volumes of sludge, with the unit operating on both the fill-and-draw and continuous-flow methods, were tried out; both with filtration of aerated sewage at various rates and without subsequent filtration. Under such conditions of operation, stabilities of 6 to 12 days were secured with aeration periods of 4 hours or more, using 25% of sludge with aeration alone. When followed by filtration at rates up to 5,000,000 gal. per acre daily, the stability was increased to 20 days or more.

This period of experimentation lasted for two months.

Subsequently the results were checked by a personal visit to the filter plant treating creamery waste at Ames, Iowa, and to the pre-aeration unit at Decatur, Illinois.

In February, 1928, a second series of tests was run with the experimental unit to determine the reduction in biochemical oxygen demand on the tentatively

adopted balance of design between aeration (activated sludge) and filtration. The results obtained after only



Lemoore Sewage Treatment Plant

two weeks operation, are shown in the following table:

	B.O.D. p.p.m.
Raw sewage	650
After 4 hours aeration and 1 hour settling	205
Settled effluent on trickling filter at rate of 6,000,000 gal. per acre per day	44
Settled effluent on trickling filter at rate of 4,000,000 gal. per acre per day	27

On the basis of these experimental data, the plant design was finally fixed.

The plant site chosen was the tract owned by the city of Lemoore, already referred to as the point of discharge of the old pressure line. This area, consisting of two tracts, of 10 and 20 acres respectively, is sandy, uncultivated land, but with the water table only a few feet below the surface of the ground.

As a part of the reconstruction, a new gravity line, 15 in. diam., replaced the worn-out 6-in. pressure line, and the pumping plant was moved to the treatment plant site.

The plant consists, therefore, of fixed bar screens with ¾-in. openings, preceding the pumps, three in number, 4-in. discharge, single port, non-clogging runner, with a design capacity of 225-250 gal. per min. against a total head of 35 feet.

These pumps discharge directly to the aeration units, four in number, equipped with Simplex mechanical aerators, so arranged that they can be operated in series or with No. 1 unit operated as a reconditioning unit for the sludge. Provision is also made for bypassing any unit.

Each aeration basin has a volume of 30,000 gal., so that when using three units, the aeration period of over four hours is provided for the design flow of 264 g.p.m. when carrying as much as 40% of returned sludge. The sewage flows from the aeration units to a sedimentation basin 25 ft. square, with corners filled, the side water depth being 10 ft., resulting in an effective volume of 5570 cu.ft. This volume allows a detention period of two hours for the design flow when carrying 40% of sludge in addition.

The activated sludge settling out in this sedimentation basin is pumped back to the re-conditioning aeration basin.

The effluent from the sedimentation basin flows into the siphon dosing chamber and thence to a trickling filter. The filtering medium is rock, with an effective area of 3900 sq.ft. and a depth of 6 ft. This gives a filtering rate of 4,250,000 gal. per acre per day for the design flow.

Sludge drying beds, having an effective area of

15,000 sq.ft., were constructed by throwing up levees around the native soil, which is a sandy loam.

Discussion

Mr. Kennedy added that the sewage effluent from the sprinkling filter comes through with a pH of 7.4 until it discharges. The water supply at Lemoore is highly charged with sulphur and devoid of oxygen. The sewage as it reaches the plant is acid, produces an acid sludge, and the handling of the acid sludge created a good deal of a problem. The major portion has been eliminated. Last fall, sludge drawn from the secondary clarifier was acid, and when discharged to beds seemed an ideal breeding place for flies, which multiplied by millions. Reconditioning of sludge and treatment with lime before discharging to beds, gave non-odorous sludge which dewatered more quickly than acid sludge. Whether it will become acid again in hot weather is one of the things to be determined.

He explained with the aid of drawings the construction of the Simplex aerator units which, instead of being set on piles, are constructed as a unit on a concrete mat, so that if they settle or tip they will do so uniformly as a unit. He also explained some of the troubles experienced with the driving mechanism.

No preliminary settlement or sludge digestion was provided because the sewage contains less settleable solids than suspended and it was felt that preliminary settlement would be small, and retention would facilitate fermentation in this highly fermented waste which he wished to avoid. It was hoped that in utilizing the data on sludge drying at Lodi on open beds, it would be unnecessary to provide sludge digestion, and if the problem can be solved without it, considerable expense will be saved.

The present problem is to eliminate odors. Some odors come from the aeration and whether they can be eliminated by changes in operation or possibly by pre-treatment with chlorine in the sewer before the sewage reaches the plant, are problems which require study. Some odor comes from the sprinkling filter, but the major portion has been from the sludge beds.

The plant is giving a great reduction in biochemical oxygen demand, and the effluent is good, allowing for present unloading of the filter.

The problem should be of interest to members of the California Sewage Works Association, particularly those who have had anything to do with milk wastes. It is a classical example of a difficult problem; of not knowing what you are doing, or all the conditions you are going to meet.

Walter C. Roberts, director of the Pacific Laboratories, and associated with Mr. Kennedy's office, stated that he had been at Lemoore for three or four days and practically eliminated odors from the water, although some sludge beds which had acid sludge dumped on them still produced odors. Some good sludge and some acid sludge is on the beds, and the difference can be noticed right away. The problem cannot be neglected because operation is 95% of the success of the plant.

Mr. Hammerly with the aid of drawings showed the principle of the operation of the Simplex aerator, which consists of a revolving disc, 5 ft. diam., with blades very much like a centrifugal propeller in a pump, set over a vertical uptake tube 4 ft. diam, extending to a point near the bottom of the hopper bottom tank in which it is placed. The revolving disc throws out a spray which absorbs atmospheric oxygen, and more liquid comes up the tube to replace that thrown out. The vertical velocity in the uptake tube is about 3 ft. per sec., and the pumping capacity at 65 rev. per min. approximately 1200 gal. per min. Troubles have been mechanical, and proper operation was restored by providing stiffer bases for the driving mechanism than those originally installed.

Experience With Flat Sewer Grades

By Andrew M. Jensen*

There is not much that I can tell you about flat grades, except to give you the experience of the city of Fresno, and some of the small adjacent cities in the valley. I know that this information will be of interest to you, because it differs so widely from the recommendations and the statements in text books. When I went to school, I was taught that you had to have a steep grade for small sewers. I knew that we didn't have them in the valley, and we still do not have them. In Fresno we have sewers of various sizes. I have prepared the following table, showing the grades of these sewers:

Sewer Diam. inches	Average grades per cent
60	0.05
54	0.087
48	0.072
42	0.08
36	0.10
30	0.089
27	0.085
24	0.091
22	0.10
20	0.10
18	0.146
16	0.11
15	0.20
14	0.15
12	0.174
10	0.17
8	0.20
6	0.30

The minimum grades in Fresno for the smaller size sewers, in which you are particularly interested, are as low as 0.15 ft. per 100 ft. of length, for a 6-in. sewer. We also have a good deal of 0.20 ft. per 100 ft. on 6-in. sewers. Most of these flat grades are at the extreme ends—the beginning of the 6-in. lateral lines around the exterior boundaries of the city—and, strange as it may seem to most of you, we have almost no trouble with them. The only time we have trouble with these flat sewers is when there are only two

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houses connected in one block. We have no odor trouble, no discharge trouble, and we get along very well with them. We flush out some of these dead ends occasionally when the maintenance crew makes its rounds through the city.

Some of the cities nearby have flatter grades than we have. In Sanger there is a good deal of 6-in. lateral sewer on a 0.1 per cent grade; also 8-in. sewer with 0.05 ft. per 100 ft., which is extremely flat, and Sanger has no particular trouble with its sewer system.

Clovis has 0.2 ft. per 100 ft. on 6-in., 0.2 ft. on 8-in., and 0.05 ft. on 10-in.

In Fresno we use a small self-propelling nozzle, that you probably all know about and use, to clean some of the smaller sewers occasionally. We have only one crew, consisting of two men, to clean and maintain the entire sewer system. They do nothing else and are able to take care of all the sewers. There are no automatic flush tanks at the end of these lines.

With this statement of facts, to be followed by the experiences of F. J. Rossi, of Modesto, and L. M. Berryhill, of Tulare, and others from cities represented here which have flat sewer grades, I think we will be able to show you that the text books are sometimes in error in that respect.

By F. J. Rossi**

Sewers laid on extremely flat grades are in the same class as an automobile with a flat tire, as they become sluggish and hard to control. Yet sewers laid on moderately flat grades may give satisfactory results.

Grades—Towns and cities situated in comparatively flat areas are confronted with sewers on flat grades. Most engineers prefer to keep the sewers on a grade that will give a velocity of two feet per second when running full. I have found that sewers laid on the grades as shown in the accompanying table give good results.

Size in.	Slope ft. per 100	Velocity ft. per sec.
4	1.2	2.0
6	0.5	1.9
8	0.3	1.75
10	0.2	1.7
12	0.15	1.7
15	0.11	1.7
18	0.085	1.7
20	0.075	1.7
24	0.058	1.7
36	0.034	1.65

**City Engineer, Modesto.

Most of the velocities in this table are less than two feet per second, but my experience shows that when a sewer becomes sluggish it builds up a head creating enough velocity to clean itself. Modesto has many sewers of 6-in. and 8-in. diameter, laid on grades as flat as 0.15 ft. per 100 ft., and there have been few cases of serious trouble. The reason for this may be that the water services in Modesto are only 4% metered; and the per capita consumption of water averages 212 gal. per day. This, no doubt, admits more water into the sewers, thus diluting the sewage and allowing an easier flow for the solids.

Lengths—Sewers of 6-in. diam. can be laid 1500 ft. in length without serious results. I have laid 8-in. sewers 3000 ft. long, and to date have experienced no trouble. Sewer lines, 10, 12, 15, and 24-in. diam., 1000 ft. long are in operation in Modesto, and giving no trouble out of the ordinary.

I find, for proper ventilation and cleaning purposes, manholes should be installed at intervals of 500 ft., but should not exceed 600 ft. in lines under 15-inch.

Stoppage—Most all cases of stoppage can be traced back to lines poorly laid, tree roots, grease from restaurants or similar establishments, sand getting into the line from street drains, or people being careless in emptying heavy paper and rags into the slop sinks.

Stoppage occurs most any place in the line, but more often in some line in a new subdivision with one or two houses only in a block. I take care of the latter condition by installing a 2-in. water line in the end of the sewer and flushing every three months.

Our most serious case of stoppage happened in a 6-in. line laid on a curve. It was necessary to construct a manhole at the center of the curve in order that the sewer could be rodded from both directions. It took two days to open up this line. An engineer should never attempt to put a small sewer line on a curve.

Cleaning—All sewers from 6-in. to 12-in. diam., are rodded and flushed once a year, and only in exceptional cases is it necessary to clean them oftener. Sewers requiring cleaning more frequently are those which receive an exceptional amount of grease, or sewers troubled with roots in the line.

Cost of Cleaning—We flush 38 miles of sewers from 6-in. to 12-in. diam. at an approximate cost of $8 per mile. This is done by rodding and flushing with a hose, using city hydrant pressure.

Odors—The most serious cases of odors are due to sluggish sewers and dead end lines with few houses in the block. Flush-tanks placed on the end of such lines

give good results, but on account of their cost, I have used instead 2-in. water lines from the main to end of sewer, and flush at three-month intervals.

No doubt the odor is caused by not having enough service connections to the main to maintain a steady flow of water to carry away the solids. It is probable that septic action has started in such cases.

Conclusion—I should say that it is much cheaper to clean sewers on flat grades occasionally than attempt to lay sewers on grades that will give sufficient velocity to keep the line clear without cleaning or flushing.

In cities of flat areas, it is hardly possible to lay lines of any great length on steep grades without some being too near the surface. To have a self-cleaning system, it would be necessary to have automatic pumping plants to raise the sewage from sumps into the main outfall sewer. The expense of such a system would be prohibitive, especially to a small municipality.

DISCUSSION

L. M. Berryhill stated that Mr. Jensen had covered the situation at Tulare in describing that at Fresno. Maximum grade is 0.3 ft. per 100 ft. with practically no trouble. Men from the street department take care of necessary work.

L. F. Barzellotti reported lowest grades he knew of, at Lodi, where maximum is 0.1 ft. per 100 ft. and minimum less than ½ in. One man takes care of all the sewers. All storm water is separated, and he thinks domestic sewage flows better on a flat grade than on a very steep one, because it consists of water carrying light floating materials which gradually move along at low velocities, but if the current is swift it slaps grease against the sides of the joints which remains and eventually produces an obstruction. Except for sticks or overalls thrown in, there have been no obstructions in Lodi sewers.

Lodi has 28 miles of sewers running generally from east to west, the natural fall being in that direction. Sewer elevations are determined by the topography and the location of Lodi, which is 50 miles from tide water 'as the crow flies'. At present sewage effluent is discharged to an irrigation canal which eventually drains to tide water, and if it becomes necessary in the future to run sewage to tide water, a sufficient grade can be obtained. This condition has resulted in some sewers being built on grades as low as ½ in. per 100 feet.

In reply to a question by Don. E. Perry, of San Anselmo, Mr. Jensen stated that in Fresno the groundwater level is 15 to 25 ft. below the surface, and no

trouble with infiltration is experienced. Some storm sewers to serve the business section of the city enter the outfall, and at other points spotted around town where sanitary sewer sizes permit, some storm water enters the sewers. He does not favor the practice, but in some cases it had to be done to better conditions. In the future, separate storm sewers will have to be built. No trouble with roots has been experienced in main or lateral sewers but house drains particularly have given trouble where eucalyptus trees are planted, and Fresno now has an ordinance requiring vitrified clay pipe with asphalt joints or cast-iron pipe with leaded joints for all house drains. The asphalt joints have been thoroughly satisfactory. All plumbing work in the house and to the city lateral must be done by a licensed plumber under the city plumbing inspector, and the line must be tested under a head of 12 ft. of water with no leaks, which has resulted in getting a good grade of vitrified clay pipe.

In reply to a question by W. T. Knowlton, of Los Angeles, Mr. Jensen stated that no trouble was experienced from running storm water into sanitary sewers because it was done only where there was ample capacity.

Mr. Perry gave the experience of San Anselmo with storm sewers which have been built under the 1911 Improvement Act by storm sewer districts to relieve overloading of sanitary sewers. Where storm sewers are within reach property owners are ordered to connect roof drains to them and disconnect them from the sanitary sewer. The problem is not difficult if approached in the right way.

Chas. F. Blood, of Sacramento, discussed the difficulty experienced with sewers in annexed territory on most of which the engineering was haphazard, with cheap sewer pipe and poor grades. Sacramento has combined sanitary and storm sewers, and all combined sewage is passed through bar screens and pumped to the Sacramento river. The total amount of water pumped from the river for the water supply of the city is about the same as the combined sanitary and storm sewage discharged.

Fresno Sewer Farm

By Andrew M. Jensen*

The method of sewage disposal employed by the city of Fresno presents some unusual and interesting phases. The final treatment is that of natural land filtration, and this is the main point of discussion.

Fresno lies approximately in the center of the great San Joaquin valley, which is practically flat, the slope at Fresno being to the southwest. The city is surrounded by agricultural territory, all of which is irrigated from a system of surface canals and ditches. The sewer system of the city is a combined system, but with only a small portion of the storm water going into the system. The population growth of Fresno has been as follows: 11,000 in 1890; 13,000 in 1900; 25,000 in 1910; 55,000 in 1920; 70,000 in 1929. There is one hundred per cent connection to the sanitary sewer system. The present average dry weather flow varies from 10,000,000 gal. per day in the winter time to 12,500,000 gal. in the summer time. The normal annual rainfall is 9 in. During storms, the sewage flow sometimes reaches a peak of 25,000,000 gal. per day, but these periods are only for a day or two at a time.

In 1907, the city purchased 812 acres of land 8 miles southwest of the city, for use as a sewer farm. This land comprises one section (one mile square), a quarter section (one-half mile square), and a small triangular piece; with the quarter section lying east of and adjacent to the northeast quarter of the full section. This makes the north side 1½ miles long, the west side 1 mile, and the south side 1 mile along the full section and ½ mile along the quarter section. The slope of the land is from northeast to southwest, the total slope being 10 ft. in that direction. The slope from north to south is approximately 5 ft. The soil is a sandy loam, the surface of which is impregnated with alkali of both carbonate and sulphate types. The outfall sewer discharges the sewage at the surface of the upper corner of the sewer farm. Preliminary treatment is provided by settling in Cameron type septic tanks, which do little more than take out some of the larger solids. The effluent from the septic tanks is distributed through ditches directly to the land for irrigation or filtration purposes.

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Until 1924, the sewage was discharged onto the sewer farm without any attempt being made to drain away the excess water. The natural ground water level not influenced by the discharge of sewage onto the sewer farm, and surrounding the sewer farm, was about 5 ft. below the ground surface. As a result the discharge of the sewage saturated the land, and more land had to be leased. Not only was all of the land upon which sewage was discharged saturated, but also great areas of land adjacent to the low sides of the sewer farm, with water standing in pools. It then became necessary to find a relief for this condition which had become intolerable.

In 1922, a special engineering commission, consisting of Geo. L. Hoxie, Fred H. Tibbetts, and myself, was appointed to study the problem and recommend a solution. The method recommended consists of the drainage of excess ground water by pumping from deep wells, using the natural soil as a filter bed. As the first step in this process, nine deep wells were drilled on the north half-mile of the sewer farm, the southerly ones being on the east and west center line of the farm, thereby being one-half mile from the south line. These wells vary in depth from 150 to 320 ft. The formations drilled through are non-water bearing sand, hardpan, clay, and water bearing sand of no particular uniformity. After being drilled, these wells were perforated in the water bearing sand strata, the perforations in all the wells but two being more than 100 ft. below ground surface. The impervious strata of hardpan and clay are not continuous, and give ready passage of water from the surface down into the water bearing strata. The wells are 16 in. diam. and arranged in 1800-ft. squares. Any sewage effluent filtered through the soil must, therefore, pass through more than 100 ft. of soil before entering a well. Of course, most of the effluent must pass through several hundred feet of soil.

When the pumping plants in these wells were put into operation, the water level on the sewer farm and surrounding territory was rapidly lowered and the objectionable condition of saturation was eliminated. The pumps have now been in operation for six years, and only enough pumps are operated to maintain the water level at 5 ft. below ground surface. Immediately after the pumps were installed, some of the land was formed into large checks or basins. These checks were not leveled and were made too large, with the result that when most of the sewage effluent which had been

turned into them had seeped away, there still remained holes and levee borrow pits full of water. During the last three years, filter beds have been prepared having level bottoms and comparatively small areas. During the summer time a considerable portion of the sewage effluent is used for the irrigation of alfalfa and corn grown on the sewer farm. Also part of the sewer farm is leased for grazing and duck club purposes. For these reasons there has been no hurry to provide filter beds sufficient in area to care for the entire flow by intensive filtration. At the present time the area of the properly prepared filter beds is sufficient to care for one-third the flow of sewage effluent with a comparatively low rate of filtration. More filter beds are being prepared all the time by the regular employees, and in about two years there will be sufficient filter area to care for the entire flow of sewage effluent.

Since the installation of the pumps, the natural ground water level of the district surrounding the sewer farm unaffected by any operations on the sewer farm, has fallen to an elevation 9 ft. below the ground surface. This is due to the dry years and the increase in pumping for irrigation purposes. The pumps of the deep well turbine type with a capacity of 1200 g.p.m. each, draw the water in the wells down to a depth of 21 ft. The amount of water pumped represents approximately 60% of the total sewage effluent discharged onto the sewer farm land. The remainder of the effluent seeps through the soil and merges with the underground water. There is no objection to this, as it simply augments the underground water supply for irrigation purposes in the surrounding district. If necessary, however, as much or more water can be pumped out of the sewer farm wells as sewage effluent is discharged onto the land. When the pumps were first put into operation, and until the water level had been lowered sufficiently, more water was pumped than was discharged onto the land. The water pumped from the wells is collected in ditches and delivered to the Fresno Irrigation District which uses it all year. The ground water level can easily be controlled by the pumps as far as ½-mile away; therefore, it has not been necessary to install additional pumps.

The areas of the filter beds now being prepared range from ½ to 6 acres; depending on construction costs. The depths to which the filter beds are filled vary from 2 to 2½ feet. The beds are filled in groups of 3 to 7 depending upon the capacities; the time of filling is approximately 50 hours; and all of the water

seeps out of the beds in 15 to 21 days. The beds are disced with every other application of sewage effluent; many of the beds, however, not needing as frequent discing. They can be refilled as soon as they are dry if desired, but a rest period of 7 or more days is usually allowed. As a matter of fact, as far as the ability of the soil to carry away the effluent is concerned, the effluent could be kept continuously on the soil for indefinite periods of time with satisfactory results.

The sewage of Fresno is mainly domestic, but there is also a considerable quantity of waste from cannery and fruit packing plants; wastes which are hard to dispose of. The tank effluent contains approximately 150 p.p.m. of suspended solids; the raw sewage as well as the tank effluent being devoid of dissolved oxygen. The sewage effluent standing in the filter beds produces no fly nuisance and none from deposits. The only odor produced is a slight marshy or swamp odor, which odor could be reduced by filling the beds to a depth of only 1 to 1½ ft., thereby letting the effluent seep away faster. The old septic tanks produce an odor and fly nuisance, and it is planned to replace these tanks with modern screens which will remove the larger suspended and floating solids.

The water pumped out of the wells is clear and sparkling and looks exactly like that from the wells which furnish the water supply for the city. By chemical analysis it has no turbidity, color, odor, organic solids, B. coli, or any compounds which indicate pollution by sewage except those dissolved salts which can not be filtered out. The chlorine and nitrate content is increased over that of the well water, but in all other respects, the sewer farm well water is the same. Even the total bacteria content of the sewer farm well water is no more than that of the city well water; the chlorine content of the former being 30 p.p.m., and of the latter 70 to 100 p.p.m.The nitrate content of the city well water is only a trace, while that of the sewer farm well water varies from 2 to 7 p.p.m. The ditches which convey the sewer farm well water have a luxurious growth of algae in them. This is true with all well water but more so with the water from the sewer farm. This means that the filtration of the sewage effluent by this method produces an absolutely stable final effluent which can be disposed of in any available manner, and it is in demand by the Fresno Irrigation District and the farmers below the sewer farm.

This method of final treatment can not be employed except where the necessary area of land can be had

economically. Also the land used as filter beds must be susceptible to drainage by deep wells. Such filtration beds must not be too near to closely built up territory. In the case of Fresno, this method has provided the cheapest possible sewage disposal outside of dilution with no preliminary treatment. With the present sewer farm area and the character of the territory surrounding it, this method will care for the sewage of Fresno in a satisfactory manner for many years to come. No doubt this method can be used by other communities having similar conditions. The cost of operating the pumps and distributing the sewage effluent to the filter beds is nominal. There is no question as to the permanency of the results now being obtained on the Fresno sewer farm, because land which has been flooded with sewage effluent continuously for the past 20 years produces as good filtration as that which has not been flooded with sewage effluent. The total operating cost of the Fresno city sewer farm is $23,000 per year, and the money received for hay crops is $8000. This makes a net cost of operation, exclusive of interest on money invested, of $15,000, or 20 cents per capita per year.

Sewage Disposal Practice in Europe

By Charles Gilman Hyde*

Foreword—During the spring and summer of 1923, and again during the summer and fall of 1928, I had the good fortune to travel rather extensively through Great Britain and western Europe, for the most part by automobile. A few sewerage works were visited in 1923. But in 1928 a definite program of inspection throughout Great Britain and in the Ruhr district in Germany was carried out. This program was planned by Dr. H. T. Calvert, chief chemical inspector of the British Ministry of Health, by George W. Fuller, consulting engineer, New York City, and by Dr. Ing. Karl Imhoff, chief engineer and director of the Ruhrverband, Essen, Germany.

Altogether, in 1928 I visited 23 plants serving 20 communities or groups of communities. These plants and projects were typical and representative of practically all of the major controlling conditions in the areas visited.

Everywhere I was received with the greatest cordiality and given the most complete information possible within the time allotted. All sewage works managers were most generous in supplying such printed or typewritten reports as were available dealing with design, construction, and operation.

Within the brief scope of this paper it will be quite impossible to give more than the merest outline of some of the major features of interest in connection with the many plants visited treating many kinds of sewage under all sorts of conditions.

Rivers and River Control—The effectiveness of river control constituted one of the most striking observations of the trip.

In Great Britain the condition of the streams is regulated by the Ministry of Health (formerly the Local Government Board) and by conservancy boards charged with the duty of redeeming or conserving the

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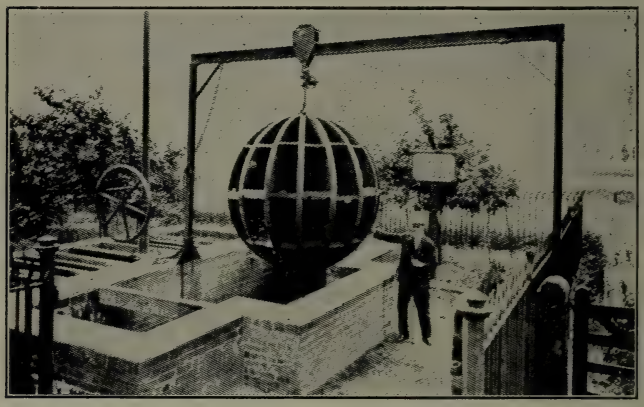
quality of the inland waterways. Among the more notable of such organizations are the Thames Conservancy Board, the West Riding of Yorkshire Rivers Board, the Mersey and Irwell Joint Committee, and the Ribble Joint Committee. Through the work of these boards, streams which had gotten far out of control are being brought back to a normal state suitable for water supply and industrial uses, capable of sustaining fish life, and fulfilling esthetic requirements.

Nowhere in the world is there to be found a more interesting, instructive, or efficient example of such control than that of the Thames river. Within the drainage area of this stream, comprising 3570 square miles above Teddington weir, 2,200,000 persons have their abode. This number is equivalent to 620 persons per square mile. Cities and towns of 2500 persons or over have an aggregate population of 1,065,000, or 300 per square mile. The total rural population, by difference, is 1,135,000, or 320 per square mile. A large portion of the water supply of London is derived from the Thames at or above Teddington weir. The water is purified by slow sand filtration plus chlorination. The earliest filters were constructed just 100 years ago, in 1829, by James Simpson. For many years the typhoid fever death rate in the metropolitan district of London has been one or less per 100,000. The river is used for all purposes for which a river can be used, throughout its course. World famous regattas are held at Henley. Small steamers ply regularly between Oxford and Kingston. House boats, some very sumptuous, are moored in great numbers along the course of the stream, especially in the lower reaches of its non-tidal portion above Teddington. Fishermen are to be seen everywhere, and all along its course are to be found bathing places and bath establishments. The water supplies of the cities in its drainage basin are taken from the stream or its tributaries, directly with filtration and chlorination, or from impounding reservoirs, or from wells in the river valleys. On its banks are the colleges of Oxford, the school at Eton, Windsor Castle and Hampton Court, many fair towns and villages, and innumerable country estates.

The control of the Ruhr by the Ruhr Talsperren-Verein and the Ruhrverband is a marvelously interesting and instructive example of the 'capitalization' of

science to the purposes of water supply, sewage treatment, and river conservation from the quantitative, qualitative, and esthetic standpoints. In its drainage basin of 1740 square miles resides a total population of 1,266,000 persons, or 720 persons per square mile. There are 47 communities in this area ranging in size from 5200 to 120,000 inhabitants, and having a total population of 935,000. In 1928 there were upward of 45 sewage treatment works and more than 90 different water works. The average daily supply of water taken from the Ruhr through infiltration conduits and shallow wells is 250,000,000 gallons. In addition to the population in the Ruhr valley thus supplied, some 2,000,000 persons in the Emscher valley, adjacent on the north, are provided with water for domestic and



Wooden 'Sewer Pill', or Flushing Ball, Used for Cleaning an 8-ft. diam. Conduit, 4.5 Miles Long, Between Settling Works at Saltley and Final Treatment Works at Minworth, England. The Ball Is Buoyant; It Produces a Vigorous Scouring Action; the Use of Chlorine Is Obviated. Similar Ball Used to Clean Siphon Between Detritus Tanks and Sedimentation Basins at Bradford, England.

industrial purposes. The water is consistently of excellent quality, obtained at a minimum of expense. Recreation parks are being developed along the course of the Ruhr, notably on Hengsteysee.

Types of Sewerage Systems—Practically throughout Great Britain and the Continent sewers are constructed on the combined principle; that is, the pipes carry both sewage proper and rain water. Among the cities I visited there were a few exceptions to this rule; for instance, Oxford, where all sewers are separate; Cheltenham, where the more recent sewers are separate; and Reading, where in general the separate system is

followed but where, during the war, some combined sewers were constructed.

Types and Condition of Sewage Treated—The circumstance of combined sewerage gives rise to relatively great volumes requiring treatment during wet weather. As a rough general principle three times the dry-weather flow is completely treated by whatever sort of treatment has been provided for the dry-weather flow in British works and elsewhere, where the controlling conditions demand it. Furthermore, as a rough general principle, from three to six times the dry-weather flow is treated in partial fashion, generally by sedimentation or subsidence only. Occasionally, however, these additional volumes of storm water are given secondary treatment, as on underdrained storm-water beds or by broad irrigation on land. Volumes in excess of six times the dry-weather flow are

First Open Sewer in the Emscher District Constructed by Imhoff in 1907 on the West Side of Bochum

usually considered to be so dilute that they may be discharged into the streams without difficulty, for in such case the streams themselves will ordinarily be considerably swollen. Of course there are many variations from these general rules. In any special instance the procedure must be governed by the controlling conditions.

From industrial towns the volume of trade waste is relatively large and frequently its character is such as to cause grave difficulties in treatment. The most difficult wastes being treated at the plants visited were wool scouring liquors—notably at Bradford, England

—gas-house liquors in practically all places, acid-iron liquors, and tannery, dye house, and brewery wastes. Birmingham, for example, boasts of 1200 different industries with a total average contribution equivalent to 20% of the normal dry-weather flow. At both Bradford and Leeds (Knostrop works) the trade wastes amount to 50% of the dry-weather flow, at Sheffield to 35%, at Manchester to 30%, and at Bolton to 25%. The bulk of the trade waste of Bradford, England, is wool scouring liquor, presenting one of the most difficult treatment problems in the world. The Essen-Rellinghausen plant in the Ruhr treats a dry-weather flow consisting of 50% trade waste and 17% ground water. Everywhere the gas-house liquors are very troublesome, demanding in their treatment an extraordinary amount of oxygen.

In residential communities the sewage is of simpler composition and more readily amenable to treatment. But even these sewages are much stronger than are American sewages from places of similar character, for the reason that the per capita consumption of water is generally but a fraction of that commonly used in the United States.

In several places visited, due to long flat outfalls or to flat grades of sewers in general, the sewage has become stale before reaching the treatment plants. Prechlorination at some properly selected point has proved valuable in reducing odor nuisance.

Land Areas for Treatment Sites—In Great Britain the general tendency or custom is to make relatively generous provision, in terms of area, of lands used or proposed for sewage treatment sites. It may be interesting to mention a few examples, as follows:

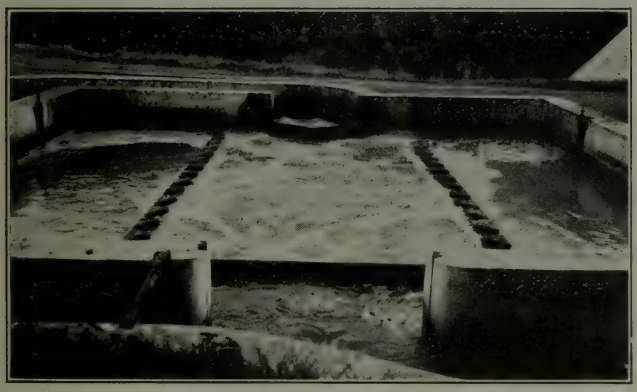
	Acres	Population
Birmingham	2,250	1,100,000
Bradford	1,800	286,000
Harrogate (Spofforth works)	77	20,000
Leeds	626	450,000
London (Barking works)	750	5,000,000
Oxford	390	57,000
Manchester (Withington works)	92	73,000
Manchester (Davyhulme works)	396	750,000
Reading (Manor Farm works)	850	85,000
Sheffield (Wincobank works)	180	520,000

In Germany and elsewhere on the continent, except where broad irrigation is practised, it is believed that the areal provision for sewage treatment is usually less generous and in some instances too conservative.

In Germany, sewage treatment works are constructed in industrial areas where possible. However, industrial works are naturally located in low-lying districts near water courses as are also the sewage treatment plants.

Many of the British works are in beautiful surroundings; some in fact in what were formerly great country estates. The most notable example is the sewage treatment plant of Bradford on the Esholt estate, with its 17th-century manor house now utilized for the offices of the works' engineering and operating staffs.

The Use of Screens—Bar screens or their equivalent, such as cage screens, are employed at practically all plants, everywhere. Occasionally tandem bar screens



Oil Separator or Collector at the Essen-Rellinghausen Plant, Ruhrverband, Germany

are employed. In all of the larger British works such screens are provided with automatic rakes or are of such a nature as to be self-cleaning. Notable examples of the latter sort are the traveling belt screens at the Crossness works, London, and the new rope screens just installed at the Davyhulme works, Manchester.

Fine rotary screens are seldom employed in Great Britain, but numerous installations have been made on the continent, particularly in Germany. The Riensch-Wurl type has frequently been used there in the past, but recently the Dorr self-cleaning rotary cylindrical type has met with favor and has been, or is proposed to be, installed at a number of plants in the Ruhr and elsewhere.

The Use of Grit Chambers and Detritus Tanks—Combined sewers, conveying large quantities of street washings and of storm water, naturally carry to the outfalls large amounts of sand and grit. It is customary at all works treating combined sewage to provide grit chambers or detritus tanks, or both. Many of these are well designed and succeed in arresting the coarser mineral matter relatively free from organic sludge. In general in Europe, as in America, the problem of grit removal is troublesome, particularly in the smaller plants. One of the most interesting smaller installations successfully meeting all flow conditions is to be found at the Velbert plant in the Ruhr. In the larger English plants, also at Paris, and elsewhere, mechanical apparatus for removing the grit is in use. There are two common types: bucket elevators delivering to cars through chutes, and clam-shell dredges.

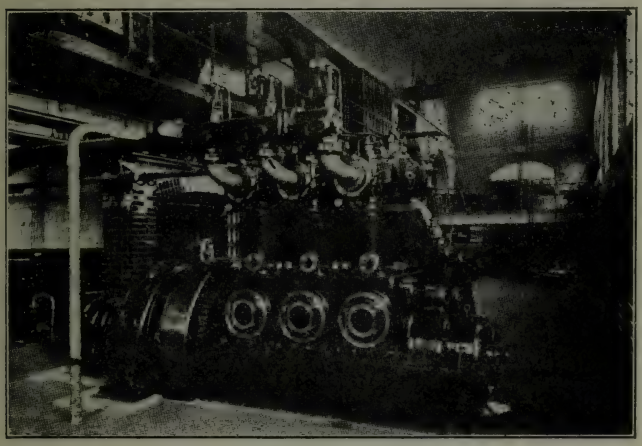
The Use of Oil Catchers—The advent of the automobile is bringing to sewage treatment works a new or at least an aggravated problem: that of mineral oil in the sewage. In English works with large pretreatment tanks, much of the oil can be arrested and skimmed off. Mineral oil is particularly troublesome in activated sludge plants of all types and reduces the efficiency of aeration.

To meet this problem, a most interesting device has been developed at the Essen-Rellinghausen plant in the Ruhr. It has proved so successful that similar installations are proposed at many other works in that district. The type is well adapted to American conditions and some such device should doubtless come into general use. The Essen-Rellinghausen device, treating the sewage of 45,000 persons, consists of a simple pyramidal tank with two air diffusor plates in the bottom. The depth is 8.2 ft. and the retention period is only 3 minutes. The air requirement is but 0.013 cu.ft. per gallon of sewage. The air serves to wash the sand, which is later deposited in grit channels or chambers. The oil carried to the surface, and thence laterally by the air, passes through slots in floating timber rafts to still chambers, whence it is removed by skimming.

English engineers, particularly at Birmingham, consider mineral oil films to be so detrimental to the best efficiency of aeration in connection with the activated

sludge process that a vegetable oil—castor oil—is employed for the lubrication of air-compressors and other mechanisms, such as agitators of the Hartley or other types.

The Use of Plain Subsidence in One-Story Tanks—Speaking generally, it may be said that plain subsidence, with or without separate sludge digestion, is



Engine (150 b.hp.) Operating on Methane Gas Derived from Separate Sluge Digestion Tanks at Saltley, England. Gas Obtained Through Floating Reinforced Concrete 'Collectors'*

most commonly used for the removal of settleable solids from the sewage. Sometimes this process is used alone, as at London during and since the war. Here the sludge is conveyed by special sludge vessels and disposed of in the North Sea. More usually, the procedure is preparatory to further treatment.

Where the activated sludge process is employed in Great Britain, plain subsidence is the usual prepara-

*The composition of the gas is: methane (CH_4)=67%; carbon dioxide (CO_2)=30%; nitrogen (N)=3%. The calorific value is 625 B.T.U's. per 1000 cu.ft. The gas yields from the primary digestion tanks at Saltley amounts to 150,000,000 cu.ft. per year, and of this quantity only 16,000,000 cu.ft. is being utilized for power purposes. Contributory population, 1927, estimated at 1,077,000. If all of the power capable of being produced was utilized, it would be sufficient to perform all the services (pumping, lighting, air compressing, etc.) required for the treatment of the entire volume of sewage from the community.

The cost of production and utilization of the power is as follows:

For collecting gas, per 1000 cu.ft.....$ 0.15

For generating electrical current, exclusive of housing or attendance charge, per kw.hr..... 0.095

The 150 h.p. unit above shown is said to earn about $7200 per annum over and above the cost of buying power. Purchased power costs 1.8 cents per kw.hr. day load, and 1.4 cents per kw.hr. night load.

First experiments were begun in 1921, and installation of practical equipment made in 1926.

tory treatment. Of the plants visited, this is the case at Birmingham, Bolton, Bury, Manchester (Davyhulme works), Reading (proposed), Stoke-upon-Trent, and Sheffield. The only exceptions, among the plants visited, are at Worcester, where a simple detritus pit precedes, and at Manchester, Withington works, where Imhoff tanks are employed. At London, and probably Glasgow, plain subsidence will precede the proposed future activated sludge process plants.

At the Werden and Oelbach plants in the Ruhr, plain subsidence is utilized, with separate sludge digestion in an abandoned quarry in the first case, and in the second case, with sludge-draining through special filter bottoms provided in the settling basins.

In America plain subsidence in one-story tanks, except in connection with separate sludge digestion, seems to be employed but rarely. Septic tanks and Imhoff tanks have largely superseded the older plain settling basins. With the development of separate sludge digestion or some other effective method of dealing with the sludge, plain subsidence will find, in fact is today finding, a much wider field of application. But septic action must be avoided, either by relatively frequent complete cleansing, as in Great Britain, or by the use of Dortmund-type tanks with regular and frequent complete sludge removal, or with mechanically cleaned tanks, utilizing Dorr, Hardinge, or other mechanical devices.

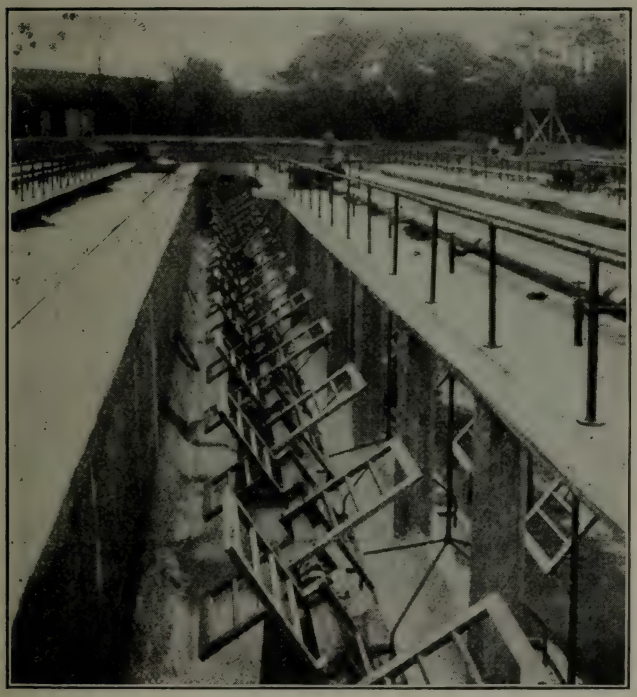
For the treatment of excess storm flows, as already suggested, plain subsidence is generally utilized in British works, either alone or with secondary treatment on underdrained storm-water sand beds, or with broad irrigation of lands, where these are available for the purpose.

In Great Britain, both horizontal flow and vertical flow tanks are employed for plain subsidence. There seems to be no great preference for either type as above the other.

The Use of Coagulated Subsidence—Coagulated subsidence is still employed at a number of large sewage works in Great Britain. Among the plants visited it was found to be in use at Bradford, Glasgow, and Leeds. At Bradford, sulphuric acid is employed to coagulate, settle, and recover the extraordinary amount of grease in the sewage from wool scouring wastes.

At Leeds, crude aluminum sulphate is used on account of the character of the trade wastes. At Glasgow, in three plants, lime and alum are employed as precipitants.

At London, Barking, and Crossness works, the addition of precipitants—lime and alum—was abandoned during the war because of the cost and difficulty of securing chemicals. Their use has not since been resumed because of the reasonably satisfactory results which are being secured by plain subsidence alone.



Air Piping and Submerged Wooden Paddles Installed in the Essen-Rellinghausen Activation Tanks; Operate on 8% Sludge; Force Sewage to Take Spiral Path Through Tanks. Effluent Goes to Funnel-Shaped Final Settling Tanks.

However, it should be said that the Thames estuary is rapidly reaching the limit of tolerable pollution and the London County Council is now proposing to apply the activated sludge process to the treatment of such gradually increased volumes of sewage as conditions may require.

The Use of One-Story Septic Tanks—Among the plants visited, septic tanks were found only at Manchester, Davyhulme works; at Reading, Caversham

works, serving 10,000 persons, where four tanks are operated by pairs in tandem preceding trickling filters; and at Oxford, where this treatment precedes broad irrigation with cropping. It would appear that proportionately more communities of size have abandoned septic tanks in Great Britain than in the United States. It is believed that septic tanks have never been popular in Germany, where every effort has been made, even in the more distant past, to maintain sewages in fresh condition. The importance and significance of this proposition seems to have been better understood and at a much earlier date in Germany than elsewhere.

For small plants serving small towns, institutions, and isolated houses, septic tanks find application in Great Britain as in America.

The Use of Imhoff or Emscher Two-Story Tanks—At only one of the British sewage treatment plants visited were Imhoff tanks found. This was at the Withington works, Manchester, where, together with plain subsidence tanks, Imhoff tanks clarify a portion of the sewage subsequently treated by double-contact bed and by the activated sludge processes.

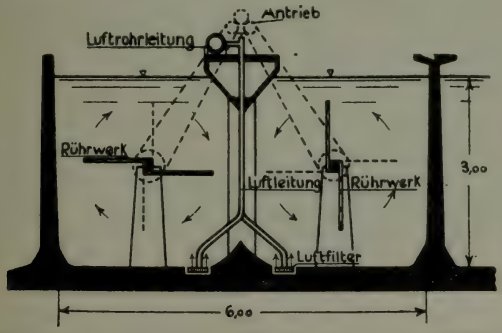
Emscher tanks (Imhoff tanks), or Emscherbrunnen as they are there called, are much used in Germany, in the Emscher and Ruhr valleys, and elsewhere. At the plants visited, this type of tank was found to be in use at Velbert, preceding submerged contact aerators, and at Essen-Rellinghausen, where these tanks originally constituted the sole treatment, except for grit removal, but now are used for pre-treatment of the sewage receiving final treatment by the activated sludge process.

The Use of Contact Beds—Contact beds have never been widely used in Germany or America, but in Great Britain it appears that they were much in vogue during the first decade or perhaps a decade and a half of the present century. The use of contact beds, as such, was found to have been abandoned at all of the plants visited with the exception of Manchester, Davyhulme, and Withington works, and of Sheffield. It appears that they are being continued in use simply because they are already in existence, and the cost of replacement with other types of treatment must be met gradually.

The principal objections to contact beds are the inevitable clogging of the porous media, necessitating

removal and washing, and the relatively low rate of successful operation per unit of area or volume. In other words, it was found to be impossible to so construct or operate contact beds that they would be self-cleaning, as are percolating or trickling filters under normal conditions.

At Bury, England, it is significant that completely clogged contact beds, 30 years old, were converted into effective percolating filters by the simple expedient of placing revolving mechanical distributors above them and dosing with settled sewage, at first limited in quantity. The material was completely redeemed without removal or washing. In six months all excess silt had been evacuated. When the contact beds were abandoned, the effluent had an oxygen absorbed value of 45 p.p.m. and contained no nitrates. When the sprinklers were introduced, the oxygen absorbed value of the effluent at once fell to 8.6 p.p.m. and the nitrates



Cross-Section of Activation Tanks for the Essen-Rellinghausen Plant*

rose to 7.2 p.p.m. No other changes in the construction of the beds were necessary.

There are still many contact bed installations in Great Britain which might perhaps be improved in the same manner, including possibly those at Manchester and Sheffield.

The concrete basins in which contact beds were formerly to be found are now used for all sorts of purposes, even as settling basins. More usually it appears

*The two rows of submerged paddles and two rows of supplementary air diffuser plates divide the tank into two operating sections. Main reliance for activation is placed on the paddles, but the air-feed pipes and air compressors are sufficient to produce activation without the use of the paddles. The paddle action opposes the rise of air bubbles from the diffuser plates, thus detaining the bubbles and increasing the air efficiency. The paddles make 7 r.p.m.

that they are being employed for activated sludge process plants of the surface aeration type, after complete remodeling.

The Use of the Activated Sludge Process—The activated sludge process has been introduced at a number of plants in Great Britain and Germany. A few installations have been made elsewhere, as in Holland. In most instances it has been developed as a final process but in at least one very important case, namely at Birmingham, it serves as an intermediate process between plain subsidence and final treatment on trickling filters, whereby the latter have been made capable of operation at double the rate otherwise possible.

In the sixteen cities in Great Britain whose treatment works I visited, eight had installed and were operating activated sludge plants of various designs, types, and capacities. In but one case was the entire dry-weather flow being thus treated. In most instances this process had been adopted as a measure or scheme of relief for existing works which had become inadequate.

Three main types of plants are in use, namely: (1) diffused aeration; (2) surface aeration; (3) a combination of the two. Three main types of surface aerators are in use: the Simplex aerators, as at Bolton and Bury; Haworth paddle wheels, as at Sheffield; and Hartley 'spiro-flow stage' paddles, as at Birmingham, and experimentally at Stoke-upon-Trent.

In a number of cases, installations of considerable size are being operated in an experimental way. This is true at Manchester, Withington works, where three types of diffused aeration are employed; also at the Davyhulme works, where a diffused aeration plant and two types of surface aeration devices are being operated side by side. At Worcester four types of diffused aeration units, with and without sludge re-aeration, are being operated.

Large-scale activated sludge experimental plants are being operated at several places, for instance London (Crossness works), Glasgow (Shieldhall works), Stoke-upon-Trent, and Essen.

In the aggregate an immense amount of information concerning this process is thus being secured.

Unquestionably the most efficient plant is that at Essen-Rellinghausen employing submerged paddles

and diffused aeration with preparatory treatment in Imhoff tanks. Here the consumption of air is only 0.14 cu.ft. per gallon of sewage treated, and the total power consumption, for both air and paddles, is only from 7 to 8 hp. per million gallons in contrast with 22 hp., or more, required elsewhere for air or paddles alone. Biochemical activity here utilizes 30% of the air as against 8%, for example, at Indianapolis.

Aside from the relatively great cost, the most serious problem connected with the activated sludge process in Europe, as in America, lies in the treatment and

Example of Open Sewer in Gevelsburg, Ruhr District, Germany

disposal of the sludge. At no plant visited was the sludge being dewatered by such devices as Oliver filters, dried in kilns, pulverized, and made into fertilizer, as is being done at a number of important plants in the United States. In most cases the sludge problem is so acute as to cause serious misgivings as to the expediency of the process under such climatic conditions as exist in Great Britain. The most successful plants in this respect are disposing of the sludge by digestion in combination with the sludge resulting from preliminary or preparatory subsidence. In this manner notable results are being secured at Birmingham and at Essen-Rellinghausen, and elsewhere.

At Essen-Rellinghausen the excess activated sludge is returned to the raw sewage entering the two-story tanks. Here it aids materially to produce a greater efficiency in subsidence.

The Use of Trickling or Sprinkling Filters (Bacteria Beds)—In both large and small British plants the trickling filter, usually called a bacteria bed, is the most common process of final sewage treatment and, all things considered, the most satisfactory both as to the dependable day-by-day character of the effluent and as to the ability to handle the resulting sludge on ordinary drying beds with little or no nuisance.

Trickling filters were found at nine of the sixteen British plants visited. This process is also occasionally found in Europe. In the Ruhr, under the Ruhrverband, it appears that there is one plant only using this process among 45 or more treatment plants.

In general, mechanical distributors are favored and fixed spray nozzles are but infrequently employed. Two types of mechanical distributors are in use: rotary and rectangular. The former are more commonly to be found at the smaller works and the latter at the larger. When the rotary type is employed the beds are usually, but not always, circular in shape, and each bed is independent of the others and dosed by a single sprinkler. The traveling rectangular distributors are obviously usable only on rectangular beds. The British distributors are manufactured by at least four firms, and devices of all of these makes have been in continuous service from 14 to 18 years with little or no trouble and virtually no maintenance charges. Of all the plants visited in Great Britain, fixed spray nozzles were found at one plant only, namely Birmingham, where 44.5 acres are so dosed. There seems to be no difference of opinion among English engineers with respect to the generally higher efficiency of mechanical distributors in comparison with fixed spray nozzles.

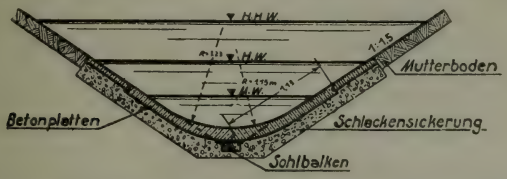
The climatic conditions generally prevailing throughout California are such as to lend themselves perfectly to the effective utilization of mechanical distributors of either type.

Depths and materials in British trickling filters are much the same as in America, except that in the older plants, at least, the materials are graded in size with coarser layers below and finer layers above. In general, perhaps, the materials in British plants average somewhat coarser; but there are some plants, however, whose top material is considerably finer than is commonly employed here.

The Use of Submerged Contact Aerators (Tauch-

koerper)—The work of Buswell at Urbana, Illinois, suggested to Dr. Ing. Imhoff the idea of developing the process of sewage treatment which is termed in America submerged contact aeration. The only plants of this type to be found in Europe are those in the Ruhr designed by Imhoff and his associates.

Much experimental work on this process has been conducted near Essen-Rellinghausen, and these tests and observations have demonstrated its efficiency and economy as a method of partial treatment. If com-



Cross-Section of Typical Open Sewage-Channel for All Flow Conditions. Employed by Imhoff in Ruhr District, Germany. Concrete or Brick Protects Lower Portion of Channel

plete treatment to produce a thoroughly stable effluent is desired, Imhoff considers that the activated sludge process is better and cheaper.

In September, 1928, it was stated that there were 10 plants in the Ruhr utilizing submerged contact aeration. Of these the largest installation was in the Velbert works.

It is of great interest to note that a new plant is being constructed to treat the sewage from a group of 8000 persons in the city of Essen. The treatment proposed is based upon experiments conducted with a small experimental plant at or near Essen-Rellinghausen and upon the practical experience already derived from the pioneer plants of the district. This new plant will embrace three stages, in series, of submerged contact aerators (tauchkoerper) and three stages of activated sludge utilizing the combined submerged agitation and air diffusion as described above. All tanks will be three metres (9.8 ft.) deep.

The Use of Intermittent Sand Filtration—The process known as intermittent sand filtration, for so many years employed with such notable success in Massachusetts, was not found at any of the plants I visited recently except in one or two instances for the treatment of excess storm water; that is, from three to six times the dry-weather flow. It would appear that this excellent process has not been developed to the same

relative extent that it has been in America, particularly in New England.

The Use of Broad Irrigation—In Great Britain, and also on the Continent, it may be said that the disposal of sewage by broad irrigation was, thirty years ago, the most common method of final treatment employed. In the earlier years raw sewage was thus treated. The process is still continued in use in numbers of places, both for sewage proper and for excess storm flows, but in general the sewage receives some form of pre-treatment. Among the 16 British plants visited, Oxford was the only place depending wholly upon this method. There the sewage receives pretreatment in crude septic-process basins constructed with earth embankments.

On the Continent the most notable use of the process is to be found at Berlin, Paris, and Milan. Many thousands of acres are thus irrigated by the sewage of Berlin and Paris, and a visit to these areas is not without interest for the engineer.

This process, with limitations, is available in California and the arid west generally and is being utilized. Here cropping of the land, as in Great Britain and on the Continent, must be made strictly subservient to the proper disposal of the sewage. The two procedures, cropping and sewage disposal, are frequently, especially during wet weather, mutually antagonistic, and it is too often the case that the latter suffers by reason of the desire to obtain satisfactory returns from the former. As in the case of fish ponds in Germany, where the raising of fish is undertaken as a commercial proposition, there is frequently a strong temptation to bypass the sewage in order to get the results sought for the presumably remunerative enterprise.

Sludge Treatment and Disposal—It would appear that the sludge problem abroad, particularly in Great Britain, has not been altogether satisfactorily solved at a large number of works, and among these preeminently are the activated sludge plants. There are, however, some notable exceptions to this statement. In general stream conservation has been the most pressing problem; and as already indicated, remarkable achievements have been secured in this particular.

There are other reasons why the sludge problem has not been solved with complete success from the Amer-

ican point of view. Odors, generally speaking, do not seem to constitute the same sort of a nuisance that they are in the United States, especially perhaps in California. Possibly the Californian nose has been too highly developed and academically educated. Only in exceptional cases is sludge dried by other means than on open beds. At Reading, England, on the Thames, in 1927, there were 320 days when some rain fell. On the average, in England and Wales, there are 187 days per year when the rainfall is as great or greater than 0.01 inch. In Scotland there are, on the average, 216 such days.

In British residential areas of good type the sludge disposal problem is profound. At some places there is a tendency to say little about the sludge disposal portion of sewage treatment plants.

Even with activated-sludge process plants producing excellent effluents, the sludge disposal problem has only occasionally been satisfactorily solved. In no instance is this type of sludge dewatered, dried, pulverized, and sold as a fertilizer as is done at Milwaukee, Pasadena, and other places in America.

Separate sludge digestion and subsequent drying upon beds or direct disposal to farmers was employed at several of the plants visited.

Barging to sea of plain settled or chemically precipitated sludge is practised by some half-dozen British cities situated on the coast or on tidal estuaries or ship canals. Vessels of 1200 to 1500 tons burden are used for this purpose.

Sludge lagooning was found to be practised at three of the plants visited, either for all or a portion of the sludge produced. The odor nuisance was extremely serious at two of these places, if not all three.

At a considerable number of places the crude (undigested) sludge is disposed of upon lands publicly or privately owned (farmers' lands). Sometimes it is trenched into the soil; sometimes disposed of by the ridge and furrow system, the ridges being cultivated.

At two of the larger places visited, namely Bradford and Leeds, the entire volume of sludge is being pressed in the usual type of pressure plate machines and finally disposed of either to farmers or by use as filling on low lying lands. At Glasgow (three plants), where the bulk of the chemically precipitated sludge is barged

to sea, a limited amount is pressed, dried, ground, and sold as a fertilizer. At Bradford, having a population of 290,000, the sludge is degreased with a resulting annual production of from 5000 to 7000 tons of salable grease worth from $200,000 to $350,000. The grease is largely derived from wool scouring liquors. To effect the removal of the grease, the sewage is treated with some 25,000 to 27,000 tons of sulphuric acid annually. At Leeds the pressed sludge cake, amounting to some 37,500 tons per annum, contains on the aver-

Beautification of Dalmarnock Sewage Treatment Works, Glasgow, Scotland, by Ornamental Planting. Total Annual Cost of Beautification Is $972

age 60% moisture, and has a nominal sale value as a fertilizer of 21 cents per ton. It is extremely difficult to get rid of, even at this price. Experiments have recently been conducted to determine the practicability of burning it. These have proved reasonably successful, no additional fuel being required. The resulting ash is worth $2.10 per ton and can be disposed of. Five tons of cake produce one ton of ash.

The Use of Chlorination—When water supplies are derived from streams, for example the Thames, the burden of purification, as related to the bacteria, is placed upon the water taker. The immediate concern of the sewage works designer and operator is to control the organic load placed upon any water course and to maintain such burden within the self-purification capacity of that body of water. For this reason chlorination of sewage effluents is rarely undertaken in Great Britain or on the Continent. In the Ruhr,

stand-by chlorination plants have been installed in some cases as an emergency control measure.

Chlorine has been employed for several years past at Bath, England, at the head of a long, flat, and excessively large outfall sewer to reduce decomposition and alleviate the odor nuisance which previously was very pronounced at the treatment works.

At Stoke-upon-Trent, the treatment plant (activated sludge) effluent, in two portions, is chlorinated as a regular procedure. Some of the sewage effluent is used for condensation purposes at a near-by electrical plant. The application of 1.75 p.p.m. of chlorine prevents the development of organisms and the consequent serious impairment of efficiency produced by gelatinous films in the condenser tubes. The remainder of the effluent is discharged into a small stream from which, a short distance away, a motor-tire factory takes its water supply. The portion of the sewage effluent so disposed of is regularly treated with 1 p.p.m. of chlorine.

The Use of Rectified Channels—In the Emscher and Ruhr valleys in Germany rectified channels for the conveyance of sewage are frequently used. Such channels serve mainly as outfall sewers or as transfer and effluent conduits at treatment plants. When employed for the conveyance of raw sewage they are very successful in keeping it fresh; in fact, partly septic sewages are thereby returned to a fresh condition.

The Use of Measuring and Recording Devices—One of the striking features of British sewage works of all sizes and kinds is the extent to which measuring and flow-recording devices are utilized. American engineers designing small plants, and city officials responsible for expenditures in connection therewith, would do well to take a lesson from their British cousins. I was deeply impressed with the fact that at every plant visited, both in Great Britain and on the Continent, works operators were able to give complete information concerning the volumes of sewage and sludge dealt with. Well equipped laboratories are to be found at the larger plants.

The Use of High Level Sewers to Avoid Pumping—Wherever possible in the larger English cities, where otherwise all of the sewage would require to be pumped, high level sewers have been constructed to deliver to treatment works without resort to pumping;

or, if pumping is required, to reduce the lift to the lowest possible terms. Such zoning is of particular interest at Leeds and London. It is, of course, also practised in this country, notably in the Metropolitan Sewerage District of Boston.

The Beautification of Sewage Treatment Areas—Another lesson which American engineers and city officials can well learn from their foreign cousins is the value of beautification of sewage and industrial wastes treatment works. Many large British plants, especially Birmingham, are remarkable in this respect. Some plants, such as those at Bath, Cheltenham, Harrogate, and Bradford, are in areas of rare natural beauty. One has the feeling of being in a great and beautiful park when visiting certain of these foreign plants. In the Ruhr every effort is being made to render the sewage treatment plants attractive and every plant visited was a marvel of neatness and cleanliness. Landscaping and planting of many of these foreign plants have been carried out on a large scale and with great skill.

The Use of Experimental Plants—It would appear that little is done in Great Britain and on the Continent in the way of the design of sewage treatment works without most careful consideration and the planning of a program of development and extension which shall apply over a long period of time. Experimental plants on a relatively large scale are set up and operated to an extent unheard of in California. The California community, when once it has the money in hand, desires that it be spent and that such works as it is intended to provide shall be built in the shortest possible time. We would do well if we spent a longer time upon our design problems and in some instances if we first experimented on a practical scale, especially where the direct data are not available, before beginning such design.

Among the 20 communities whose sewage treatment works were visited by me in 1928, ten were conducting various sorts of experiments with devices of relatively large capacity. Seven of these were carrying on large-scale activated sludge process experiments.

Some References—

The Arithmetic of Sewage Treatment Works, by Imhoff and Fair; John Wiley & Sons, New York City (1929).

Solving Sewage Problems, by Fuller and McClintock; McGraw-Hill Book Co., New York City (1926).

The Activated Sludge Process, by A. J. Martin; Macdonald & Evans, London, publishers (1927).

Der Ruhrverband, Zweite Auflage, Essen, July, 1928, by Imhoff; Carl Heymanns Verlag, Berlin, W. 8.

25 Yahre Emschergenossenschaft, 1900-1925, Essen.

Engineering News-Record, McGraw-Hill Publishing Co., Inc., New York City.

Program, Second Annual Convention

Hotel Oakland, Oakland, October 7-10, 1929

Monday, October 7

8 a.m.—

Meet at San Carlos hotel, Monterey, for trip to sewage treatment plants at Carmel, San Juan, Gilroy, Santa Cruz, and Montezuma. Barbecue Lunch at Gilroy Golf Club; guests of The Dorr Co.

Tuesday, October 8

10 a.m.—

Address of welcome—William H. Parker, commissioner of streets, Oakland.

Response—Leon B. Reynolds, president, California Sewage Works Association, and professor of sanitary and hydraulic engineering, Stanford University.

Business meeting.

Discussion of plants visited Monday.

'Oil Exclusion and Removal', F. A. Batty, civil engineer, Los Angeles. Questions and answers.

12 noon—

Luncheon as guests of the American Concrete Pipe Co. at its Oakland plant, followed by an inspection of the Hume centrifugal process of concrete pipe manufacture.

2 p.m.—Symposium, 'Sewage Disposal and Costs'.

'Digestion of Activated Sludge at Pomona', F. H. Froehde, city engineer.

'Separate Industrial Sewers and Chlorination at Tulare', R. M. Berryhill, city manager.

'Foaming and High-Rate Land Disposal at Visalia', L. H. Gadsby, city engineer.

'High-Rate Sand Disposal at Modesto', F. J. Rossi, city engineer.

'Pumping and Foaming at Stockton', W. B. Hogan, city manager.

'Gas Burning and Chlorination at San Bernardino', F. S. Currie, consulting engineer, San Bernardino.

'Cost Keeping System of the Los Angeles County Sanitation Districts', A. K. Warren, chief engineer.

'Fly Control at Sewage Treatment Plants', W. B. Herms, professor of parasitology, University of California.

Discussion on this paper by Hilliard Hall, Grand Canyon, Arizona; R. F. Goudey, state department of public health, Los Angeles; representatives of Los Angeles county sanitation districts; and A. M. Jensen, commissioner of public works, Fresno.

Wednesday, October 9

10 a.m.—

'Sewer Grades', A. M. Rawn, sanitation districts, Los Angeles county.

'Relative Costs of Sewerage', D. E. Perry, manager and assessor, Marin Sanitary District No. 1, San Anselmo.

'State Supervision of Sewage Disposal', C. G. Gillespie, chief, bureau of sanitary engineering.

'Responsibilities and Procedures of Municipalities', B. J. Pardee, city manager, Visalia.

12 noon—

Luncnheon as guests of N. Clark & Sons, (and Gladding, McBean & Co.), clay products plant, Pacific avenue, west Alameda; followed by inspection of vitrified clay pipe manufacture.

2 p.m.—

Joint meeting with the engineers' section, League of California Municipalities.

Symposium, 'Sewage Disposal to Salt Water'.

'Float Surveys and Wrought-Iron Outfalls at Santa Cruz', C. G. Hyde, professor of sanitary engineering, University of California.

'B. Coli Surveys at Hyperion Outfall Sewer, Los Angeles', W. T. Knowlton, city sanitary engineer.

'Settling Tanks for Bay Outlets at San Diego', F. M. Lockwood, city manager.

'Slough Disposal at San Anselmo', C. C. Kennedy, consulting engineer, San Francisco.

'Experimental Work on Outlet Structures for Los Angeles County', A. W. Rawn, assistant chief engineer, Los Angeles county sanitation districts.

'Concrete Pipe Outfall Sewer and Pumping at San Rafael', H. K. Brainerd, city engineer.

'Bay Disposal and Chlorination at Newport Beach', R. L. Patterson, city engineer.

'Sewage Disposal in California', L. B. Reynolds, Stanford University.

Wednesday Evening, October 9

Industrial Exposition and Dance (with League of California Municipalities).

Thursday Evening, October 10

Banquet at Hotel Oakland (with League of California Municipalities).

Minutes, Second Annual Convention

October 8 and 9, 1929

William H. Parker, commissioner of streets of Oakland, welcomed the second annual meeting of the California Sewage Works Association to Oakland, and offered the services of his department through T. F. Eastman, drainage engineer, to help out the convention.

President Reynolds responded. (See Page 5.)

The president called for the secretary-treasurer's report and announced that an auditing committee consisting of Parkes and Allen would make a report before the secretary-treasurer's report would be accepted. After the report of the auditing committee by W. A. Allen, the secretary-treasurer's report was approved.

The president then called on the various committees:

Program Committee—B. J. Pardee, chairman, reported that he had delegated authority and all members of the committee had worked.

Membership Committee—Philip Schuyler, chairman, reported no activity as a committee, but pointed to the increased growth brought about by individual members, and by publicity through Western Construction News.

Sewer Maintenance Committee—G. A. Parkes read W. T. Knowlton's report submitted by J. D. Faulkner, member of the committee. The committee urged that records of cost of maintenance be kept on uniform report forms.

Discharge of Industrial Wastes Into Sewers Committee—Report was made by F. J. Rossi, chairman, who stated that progress had been made, and 55 replies to 63 questionnaires sent out had been received. He asked further time to get the committee together. By general consent it was decided that Rossi would continue working on this report and use it for material for a paper at the next meeting.

Educational Committee—A. M. Rawn submitted a final report of the committee, which arranged the course in sanitary engineering at the University of Southern California Short School in Public Administration, June 17-22, 1929. A complete set of papers as given accompanied the report, and abstracts will appear in the 1929 California Sewage Works Journal.

Editorial Committee—Report read by acting secretary. Papers from first meeting were printed in the

first issue of the Journal, and those of the Fresno conference and the second annual meeting will be printed in the 1929 Journal.

Standard Report Form Committee.—C. C. Kennedy read a report which had not been submitted to the other members of the committee. The report gave the purpose of standard forms "that the most suitable sewage treatment may be secured most economically". It should show: 1. Plant construction cost. 2. Plant operation cost. 3. Operation results.

Although not technically a committee report, President Reynolds called on Philip Schuyler to give an account of Senate Bill 652 which was pocket vetoed by the Governor. Schuyler reported that Governor Young and Alexander Heron, director of finance, had promised that sewage research would be strongly supported by the state, but no definite action had been taken.

President Reynolds announced that the resolutions committee had been appointed, consisting of A. M. Rawn, Alva Smith, and J. H. Van Norman, and requested that this committee submit its report at the Wednesday morning session. Schuyler was asked to frame a resolution on state-aid sewage research.

President Reynolds then called for an expression of opinion as to whether or not a spring meeting should be held, and whether the trip should precede the general meeting. It was unanimously agreed by informal vote that a spring meeting should be held and that the trip should be arranged for the first day.

G. F. Hyatt, of the American Concrete Pipe Co., announced the details for transportation to their plant for luncheon and inspection.

President Reynolds next called on the secretary pro-tem to make an announcement regarding traffic officer Tyre Martin who, while conducting the caravan October 7, had an accident, cutting his trousers badly and bruising his face, hands, and body. It was voted that a collection be taken and that the entire collection should go to the traffic officer. The total collection was $37.15.

President Reynolds next called upon the nominating committee, which submitted its report:

President—F. A. Batty.
1st Vice-President—B. J. Pardee.
2nd Vice-President—W. A. Allen.
Secretary-Treasurer—E. A. Reinke.
Director—Chester A. Smith.
Board of Control—Léon B. Reynolds.

President Reynolds then announced that according

to the provision of the constitution, no officer or director, with the exception of the secretary-treasurer, could be re-elected for a second term. Schuyler nominated Alexander Bell, Pacific Coast Manager, Wallace & Tiernan Co., Inc., for a member of the board of directors; insisting that the equipment and materials manufacturers should always be represented on the board.

President Reynolds then called for a vote on each office. For brevity, nominations were closed, each in turn for the president, 1st vice president, 2nd vice-president and secretary-treasurer; and in each case the secretary pro-tem was instructed to cast a vote for the membership in favor of the nominee. They were duly elected and announced as elected each time by President Reynolds.

Ballots were then distributed for election of director to the governing board. There were no additional nominations from the floor and nominations were closed with the two candidates, Chester A. Smith and Alexander Bell. The poll of votes gave Alexander Bell 32 and Chester A. Smith 20, and the president declared Bell elected.

President Reynolds then relinquished the chair to the secretary pro-tem, and the election of a member to the board of control proceeded. After the ballots were closed, President Reynolds was declared the representative to the national board of control.

E. L. Wright of Orland suggested that the name of the organization be changed to drop the word 'Sewage'. It was referred by President Reynolds to the governing board.

Under the discussion of plants visited, F. V. Hammerly described the Watsco aerator at Montezuma, and gave a history of its development. Gillespie, Rawn, and Burgess discussed the plant at Gilroy.

F. A. Batty read a paper on 'Oil Exclusion and Removal', which was discussed by G. A. Parkes.

The opening attendance was 42 and reached a maximum of 76 for the morning session. The morning meeting adjourned at 11:55.

During the luncheon hour the members were the guests of the American Concrete Pipe Co. at its Oakland plant, where a delightful luncheon was served, followed by an inspection of the manufacture of centrifugally cast concrete pipe by the Hume process.

Afternoon Session, October 8

Meeting was called to order at 2:15 p.m.

John Spencer, of the State Fish and Game Commission, discussed Batty's paper on 'Oil Exclusion and Removal'.

Alva Smith read a paper 'Digestion of Activated Sludge at Pomona', by F. H. Frochde, city engineer, which was discussed by Kennedy, Goudey, Haseltine, and Alva Smith.

R. M. Berryhill, city manager, read a paper 'Separate Industrial Sewers and Chlorination at Tulare' which was discussed by Perry and Beyer.

L. H. Gadsby, city engineer, read a paper on 'Foaming and High Rate Land Disposal at Visalia'; discussed by W. F. Rantsma.

F. J. Rossi, city engineer, read a paper 'High Rate Land Disposal at Modesto'; discussed by John Mason and Gillespie.

W. B. Hogan, city manager, read a paper on 'Pumping and Foaming at Stockton' which was discussed by DeMartini and Kennedy.

F. S. Currie, consulting engineer, read a paper on 'Gas Burning and Chlorination at San Bernardino', which was discussed by A. M. Kivari.

An abstract of A. K. Warren's paper, 'Cost Keeping System of Los Angeles County Sanitation Districts', was read by the acting secretary.

W. B. Herms, professor of parasitology, University of California, presented a paper 'Fly Control at Sewage Treatment Plants', which was discussed by Goudey, Rawn, Rantsma, Foreman, Batty, and Gray.

At the request of the chairman, Gillespie explained features of the 'Sewer Rental' bill (S. B. No. 651), which was killed in committee at the last legislature. He stated the chief criticism of the bill was that some of the legislators felt that sewer service, like health service or education, could not be paid for on the basis of ability to pay, and that such a bill might result in poor people not having sewerage facilities. Gillespie added that the same argument might be added against making water supply a utility, but it is well known that everybody avails himself of water service.

Attendance averaged 70. Meeting adjourned at 5:02 p.m.

Morning Session, October 9

Meeting was called to order at 10:05 a.m. by president Reynolds, with 61 present.

The resolutions committee reported three resolutions: one acknowledging assistance of certain commercial firms in arranging for the second annual meeting; another thanking the governor and state director

of finance for their interest in state-aid sewage research, and urging prompt action; and the third expressing appreciation for the work of the retiring officers of the association. All three resolutions were unanimously adopted.

A. M. Rawn read a paper on 'Sewer Grades', which was discussed by Crist, Rantsma, Batty, Kennedy, Parkes, Castello, Perry, and E. L. Wright.

D. E. Perry read a paper on 'Relative Cost of Sewerage', which was discussed by Rantsma and Steward.

C. G. Gillespie, chief, State Bureau of Sanitary Engineering, read a paper on 'State Supervision of Sewage Disposal'. Following Gillespie's paper, the discussion of the financial support of the Bureau of Sanitary Engineering resulted in C. C. Kennedy being instructed by the chair to submit a resolution concerning additional support at a later session.

B. J. Pardee, city manager of Visalia, read a paper 'Responsibilities and Procedures of Municipalities', which was discussed by Lee, Crist, Gillespie, Parkes, and Alva J. Smith.

The meeting adjourned at 11:50 a.m. to the Hotel Oakland dining room, where the members were luncheon guests of N. Clark & Sons and Gladding, McBean & Co. Following the luncheon, the members visited the N. Clark & Sons vitrified clay products plant at West Alameda.

Afternoon Session, October 9

A joint meeting with the engineers' section of the League of California Municipalities was turned over by President Blood of the engineers' section to President Reynolds at 2:35 p.m. Attendance 125.

C. C. Kennedy presented a resolution concerning support of the State Bureau of Sanitary Engineering, which was unanimously adopted.

A symposium 'Sewage Disposal to Salt Waters', included papers by the following authors: C. G. Hyde, W. T. Knowlton, F. M. Lockwood, C. C. Kennedy, A. M. Rawn, H. K. Brainard, and R. L. Patterson, Knowlton's paper was read by G. A. Parkes; Kennedy's paper was discussed by H. N. Bishop, and Rawn's paper by Hyde and Crist.

L. B. Reynolds (president) read a paper on 'Sewage Disposal in California', which was illustrated with lantern slides of a number of typical sewage treatment plants.

Meeting adjourned.

Respectfully submitted,
R. F. Goudey, Secretary-Treasurer Pro-tem.

RESOLUTIONS UNANIMOUSLY ADOPTED AT SECOND ANNUAL CONVENTION OF THE CALIFORNIA SEWAGE WORKS ASSOCIATION

Oakland, California, October 8 and 9, 1929

Resolution thanking firms that helped to make this convention a success. Introduced by R. F. Goudey.

"Whereas, certain commercial enterprises have contributed greatly to the success of this, the Second Annual Convention of the California Sewage Works Association, and

"Whereas, the Association wishes to acknowledge with gratitude such kindly effort,

"Now Therefore Be It Resolved, that the thanks of the California Sewage Works Association be extended to:

Western Construction News,
Wallace & Tiernan Co., Inc.,
The Dorr Co.
American Concrete Pipe Co.
Gladding, McBean & Co. and
N. Clark & Sons Co.,

for their generous help during the Association's 1929 meeting; and that the secretary be instructed to furnish a copy of this resolution to each of the foregoing companies."

Resolution concerning state aid to sewage research. Introduced by Philip Schuyler.

"Whereas the Honorable C. C. Young, governor of California, and Alexander R. Heron, state director of finance, have signified their intention to provide adequate funds for financing 'State-Aid Sewage Research' (in lieu of S. B. 652 which was pocket-vetoed) and their desire to formulate the necessary state legislation that will secure a continuous program of research from year to year,

"Therefore Be It Resolved, that the secretary be instructed to extend, in writing, to Governor Young and Mr. Heron, the appreciation of this body together with the urgent request that they designate a time and place for an early meeting with representatives of this body to discuss the details for getting this research underway as soon as possible."

Resolution expressing appreciation of work of retiring officers. Introduced by W. F. Rantsma.

"Whereas, the members of this, the California Sewage Works Association, are aware of the earnest

and sincere efforts of the officers of the Association during the past year in behalf of the organization,

"Now Therefore Be It Resolved, that the sincere appreciation of this association be, by this resolution, conveyed to:

The retiring president—L. B. Reynolds.

The retiring Board of Control Member — C. C. Kennedy.

The retiring Director—F. M. Lockwood.

and to all other officers of the Association for their efficient and capable management of the affairs of the Association during the year 1929."

Resolution concerning support of State Bureau of Sanitary Engineering.

"Whereas, the efficient operation of sewage treatment and water purification plants is contingent upon adequate supervision by the Bureau of Sanitary Engineering of the State Department of Public Health, and

"Whereas, it has been shown at this meeting that the Bureau of Sanitary Engineering is inadequately financed and the present personnel is insufficient to furnish such supervision,

"Be It Resolved, that the representatives of this Association appointed to confer with the governor and director of finance be authorized to urge such additions to the personnel of the bureau as will make it possible for the bureau to bring the operation of sewage and water purification plants to the highest efficiency."

Sewage Treatment Plants Visited

October 7, 1929

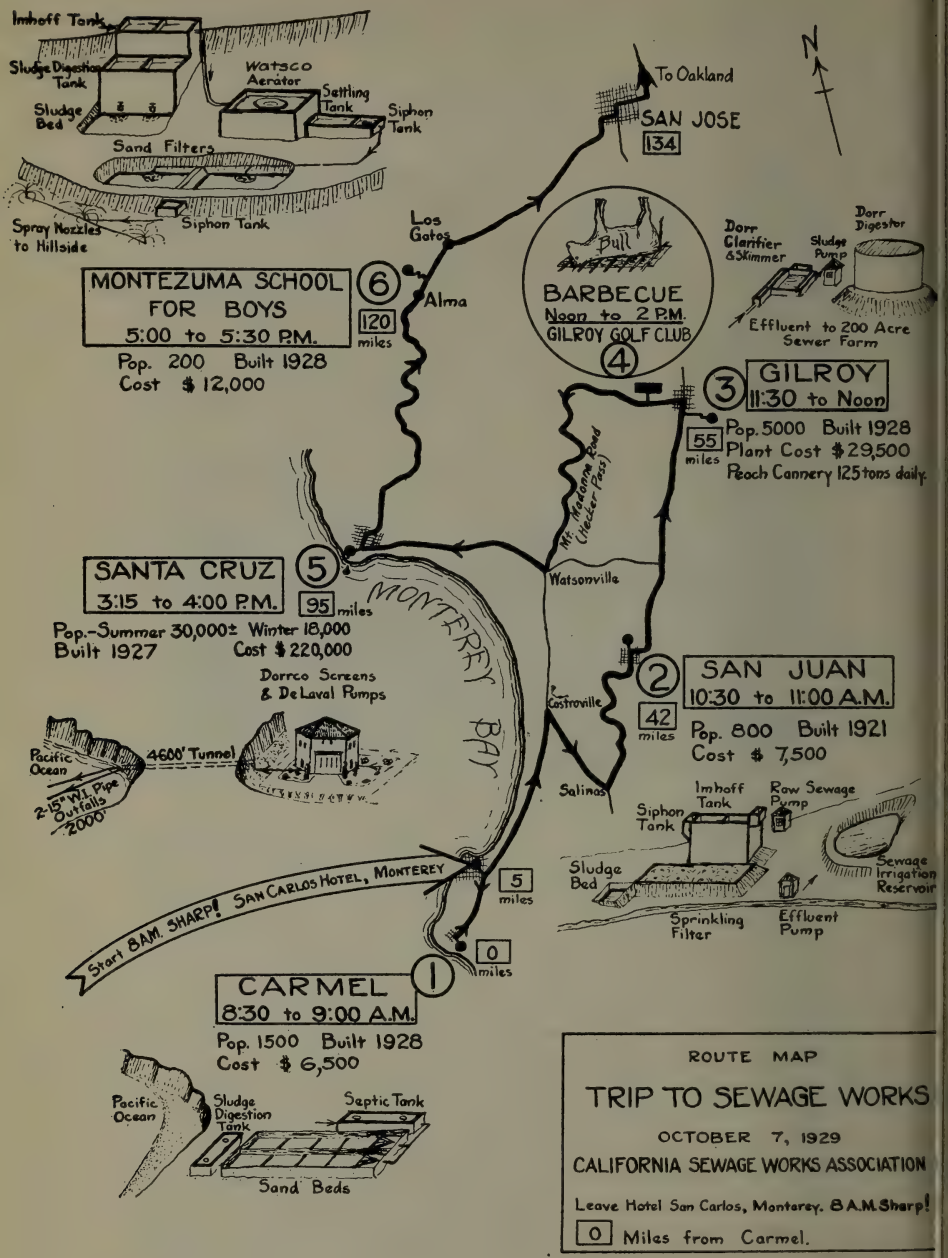
(See Map, page 74, for location of plants.)

Carmel Plant—This plant consists of a septic tank, sand beds, sludge digestion tank, and burial pits for sludge. It was designed as a temporary plant for 1500 population and was to be used for only two years. The plant has now been operating four years and handles a normal population of 3500 with a peak of 8000. The sand beds are 20 by 120 ft., with a slope of 3 in. on the 20-ft. length. Their surfaces are about 20 ft. above the water table. The plant cost $5500 and the operating cost is $100 per month.

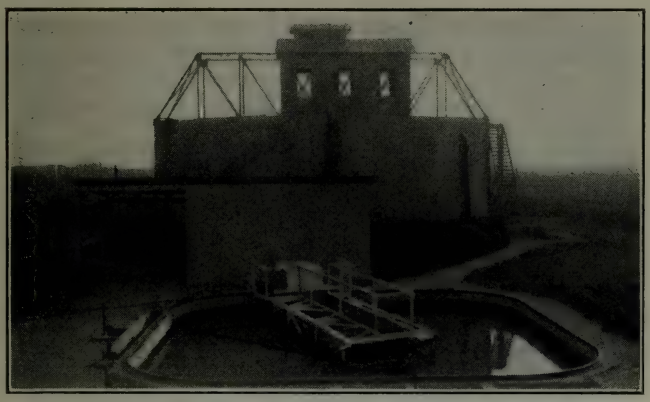
Sand Filter Beds at Carmel Sewage Treatment Plant

San Juan Plant—This plant, built in 1921 for $7500, now serves a population of 1200. It consists of a raw sewage pump, Imhoff tank and siphon tank, sprinkling filter, sludge bed, effluent pump, and reservoir for storing the effluent. This effluent is used for gravity irrigation of a pear orchard and is quite satisfactory. The flowing-through chamber of the Imhoff tank is separated from the gas vents by planked partitions. These allow the escape of gas through cracks into the center of the tank and the rising bubbles interfere with sedimentation.

Gilroy Plant—This plant handles peach cannery waste, 125 tons daily during the season, in addition to domestic sewage for a 5000 population. It consists of a Dorr clarifier and skimmer, sludge pump, Dorr digestor, sludge beds, and 200-acre sewer farm for effluent disposal. The plant was built in 1928 for $29,500. At Gilroy a ton of raw peaches produces the same


Imhoff Tank
Sludge Digestion Tank
Watsco Aerator
Settling Tank
Siphon Tank
Sludge Bed
Sand Filters
Siphon Tank
Spray Nozzles to Hillside
To Oakland
SAN JOSE
134
N
Los Gatos
Alma
MONTEZUMA SCHOOL FOR BOYS
5:00 to 5:30 P.M.
Pop. 200 Built 1928
Cost $ 12,000
6
120 miles
Bull
BARBECUE
Noon to 2 P.M.
GILROY GOLF CLUB
4
Dorr Clarifier & Skimmer
Sludge Pump
Dorr Digestor
Effluent to 200 Acre Sewer Farm
3
GILROY
11:30 to Noon
Pop. 5000 Built 1928
Plant Cost $ 29,500
Peach Cannery 125 tons daily.
55 miles
Mt. Madonna Road (Hecker Pass)
Watsonville
SANTA CRUZ
3:15 to 4:00 P.M.
95 miles
5
MONTEREY BAY
Pop.-Summer 30,000± Winter 18,000
Built 1927 Cost $ 220,000
Dorrco Screens & DeLaval Pumps
Pacific Ocean
4600' Tunnel
2-15" W.I. Pipe Outfalls 2000'
Castroville
42 miles
2
SAN JUAN
10:30 to 11:00 A.M.
Pop. 800 Built 1921
Cost $ 7,500
Salinas
Imhoff Tank
Raw Sewage Pump
Siphon Tank
Sludge Bed
Sewage Irrigation Reservoir
Sprinkling Filter
Effluent Pump
Start 8 A.M. SHARP! SAN CARLOS HOTEL, MONTEREY
5 miles
0 miles
1
CARMEL
8:30 to 9:00 A.M.
Pop. 1500 Built 1928
Cost $ 6,500
Pacific Ocean
Sludge Digestion Tank
Septic Tank
Sand Beds
ROUTE MAP
TRIP TO SEWAGE WORKS
OCTOBER 7, 1929
CALIFORNIA SEWAGE WORKS ASSOCIATION
Leave Hotel San Carlos, Monterey. 8 A.M. Sharp!
0 Miles from Carmel.

amount of sludge as 120 people per day. In 1928 lime was added at the rate of 50 lb. per day. The pH during the fall of 1929, averaged 6.4. (See description of plant and results obtained in **Western Construction News,** November 25th, 1929, issue.)



Dorr-Equipped Separate Sludge Digestion Plant, Gilroy, California.

Montezuma School for Boys—The plant was built in 1928 for $12,000. It serves a population of 225 and consists of a modified Imhoff tank, sludge digestion tank, sludge bed, Watsco aerator, settling tank, siphon tank, sand filters and spray nozzles for final disposal of the effluent. The elaborate plant layout is required because the school is critically located on the catchment basin for the water supply of San Jose. (A description of the plant was published in **Western Construction News,** June 10th, 1928 issue, pp. 359-361.)

Imhoff Tank in Background, Aeration Chamber in Center, and Secondary Settling Basin in Foreground, at Montezuma School for Boys.

The Watsco aerator, designed by F. V. Hammerly of the Water Works Supply Co., San Francisco, is the result of a study made after several years of observation and investigation of sewage aeration. It was designed to introduce air into sewage, treating it in a more intimate and efficient manner than is possible in the conventional activated sludge method. The requirements of a well-operated sewage aerating plant are: a slight excess of oxygen in all places within the tank at all times to support the growth of oxidizing bacteria; positive mechanical mixing of activated sludge with the sewage treated; and a positive means to avoid accumulations of activated sludge within the

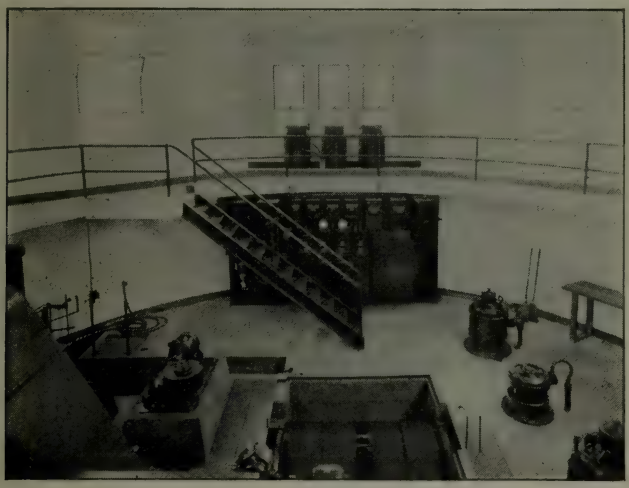
Elevated Spray Nozzle, 10 ft. High, Dosed from Siphon Box at Montezuma School.

tank. If the sewage is kept in active circulation, a slight excess of oxygen will be obtained; this active circulation will also result in mixing the activated sludge and incoming sewage; and accumulations of activated sludge can be prevented by maintaining certain minimum velocities in the bottom of the tank. In each case, therefore, adequate velocity or circulation of the solutions is required.

Early aerators investigated by Hammerly were not economical in horsepower demand or lost too much velocity head when educting air. In the perfected Watsco aerator sewage is taken from the top of the tank and pumped vertically downward and discharged through a throat section where complete emulsion is effected. An inverted truncated cone, placed in the tank, utilizes

the air lift effect (due to the large amount of air educted) to circulate the solutions in a vertical direction. The emulsion is forced down against the bottom of the tank and directed upwards by sloping sides to the periphery of the tank. (The Watsco aerator was described in detail in **Western Construction News,** October 10th, 1929, issue.)

Santa Cruz Plant—This plant was built in 1927 at a cost of $220,000 for a population of 18,000 in winter and 30,000 in summer. It consists of a screening-pumping



Interior of Sewage Screening-Pumping Plant, Santa Cruz, California

plant containing two bar-screen channels, a 25,000-gal. sewage pump, a pump chamber, two rotary screen chambers, one screenings pit, one ejector pit, with Dorr screens, bucket elevators and ejector, and DeLaval pumps. There is a 4600-ft. tunnel and two 15-in. wrought iron outfall pipes, 2000 ft. long, for disposal of the effluent. (A full description of the plant was published in **Western Construction News,** October 10th, 1928, pp. 614-625.)

Oil Exclusion and Removal

By F. A. Batty*

The exclusion and removal of grease or oily substances from sewer systems is a subject upon which there is little information available, and it appears to be a condition which has received little consideration from those responsible for the design and operation of sewage systems and treatment plants.

The damage ensuing from stopped up sewers caused by congealed grease can easily amount to many thousands of dollars, and injury or even death, to say nothing of property damage, may result from an explosion caused by the ignition of gases generated from petroleum waste or volatile oils that have been permitted to be discharged into the sewage system. Grease and other trade wastes are known to be detrimental to the proper operation of sewage treatment plants, and the removal of grease from screens is a constant expense.

Greasy or allied substances detrimental to the proper functioning of sewers may be classed under the following heads:

Grease, from the preparation of foods.
Soapy effluent from laundries, etc.
Waste from petroleum products.
Waste from garages, etc.

Grease from the Preparation of Food—Grease enters the sewer system in proportion to the population served. It is estimated that the one million people connected to the sewage system of the city of Los Angeles, contribute 22 tons of grease per day. (This does not include the outside contributing cities). Most of this grease enters the system through the individual house connections and does not materially effect the functioning of the sewers, except in the case of larger restaurants, meat packing houses or like establishments, the grease from which can be prevented from entering the sewers by well designed grease traps, properly maintained.

This necessitates periodical inspection by city inspectors working under ordinances that govern these operations and provide penalties for non-observance. Los Angeles has these ordinances, but unfortunately does not have sufficient personnel in the engineering

*Engineer, Maintenance of Sewers, City of Los Angeles, and 1930 President of C.S.W.A.

department to see that they are enforced, consequently there are times through carelessness and neglect that quantities of grease enter the sewers.

This grease congeals usually a few hundred feet below the connection, particularly when the velocities are low, and eventually completely blocks the sewer and has to be removed by rods and scrapers.

Soapy Effluent from Laundries, etc.—Soapy effluent from laundries, etc., acts in the same general way as grease, the operation of depositing this substance on the sides of the sewer is slower, each successive layer being very thin. This material in time becomes extremely hard, the removal of which is difficult and can only be accomplished by dragging scrapers through the pipe, with a drag pulled by a truck or power hoist. It is almost impossible to entirely remove this cement-like substance from the pipe as the drags have to fit the pipe loosely.

Soapy effluent cannot be prevented from entering the sewer by means of a similar device to a grease trap and I recommend that wherever possible, laundries be built along the larger sewers, as they do not seem to be affected in the same way as a small pipe, probably because of more dilution.

Waste from Petroleum Products—From time to time a large quantity of heavy black oil is allowed to enter the sewer system. The first knowledge we have of this is the appearance of the oil at the screening plant at the ocean end of the system, which is 25 miles below the possible source of the trouble. This oil is very detrimental to the operation of sewage screens, causing blinding, and can only be removed from the screens by the use of steam.

We have made several attempts to locate this trouble and prevent its recurrence, but have so far failed.

Waste from Garages, etc.—Recently an inspection was made of a number of garages in the city, and in almost every case, oil or chemicals containing grease were allowed to enter the sewer. Most of these garages were provided with sand or grease traps, but in many instances they were not properly maintained.The department mailed to every garage and automobile repair business in the city copies of an ordinance providing against improper use of sewers and setting forth penalties therefor. At this time a second inspection of these premises has not been made.

Gasoline—Volatile and Explosive Gases—A large quantity of oil or similar substance that generates gas of an explosive nature, finds its way into the sewer

system from various sources that at present are indetermined, producing a most dangerous situation. Within the past few months a severe explosion occurred in the Slauson avenue outfall sewer between Avalon boulevard and Western avenue, causing the covers of 30 manholes to be blown into the air, some of them, according to eye witnesses, as high as 25 ft. Several of these 250-lb. covers struck the pavement with such force that they were broken in pieces. At the time the explosion occurred, this street was crowded with traffic. Fortunately no person was injured or automobile damaged. The department later obtained the use of a gas detector from the Los Angeles Gas Co. and found that this sewer contained gas in explosive quantities in many places. The department is now negotiating for the purchase of a similar gas detector for ascertaining the source of and preventing a re-occurrence of this dangerous condition. This gas was probably ignited by a city asphalt heater that was working along the line of the sewer.

Grease Removal—This city last fall began a series of experiments on grease removal under the direction of W. T. Knowlton, and in charge of G. A. Parkes. These experiments were conducted on a small scale and satisfactory findings resulted.

Sufficient money has been appropriated to continue these experiments on a much larger scale. It is hoped that the results will be as satisfactory.

The intention is to construct the final grease removal units at the screening plant at the lower end of the sewer system.

A paper on this experiment was read at the Sanitary Engineering Section of the Southern California School of Citizenship and Public Administration last June. (See synopsis on page—).

In conclusion I would state that the grease problem has two distinct phases. 1st, The prevention of large quantities of grease, etc., from entering the sewers, to reduce the cost of maintenance and prevent costly damages. 2nd, The removal of grease, etc., at the lower end of the sewer, to make the disposal of the effluent more satisfactory. The solving of either one of these problems will not materially help the other.

DISCUSSION

Oil Exclusion and Removal—G. A. Parkes, engineer, Los Angeles sewer department, remarked that most people thought of grease removal in terms of individual house grease traps which he does not consider reasonable or desirable. However, large grease and oil

discharges must be controlled, if possible, at the source. At Los Angeles; fine screens are used followed by ocean disposal. Finely divided or emulsified grease goes through the sewers, but does not diffuse in the ocean and comes back to shore. Experiments show that vigorous aeration, probably not over 20 seconds, followed by one to three minutes' retention, brings the grease up to the surface of the sewage, where it may be removed by several methods. The tanks are designed with steeply sloping bottoms to keep sludge moving to the center. Los Angeles has tried out Imhoff's design and finds that their own is better.

John Spencer, of the State Fish and Game Commission, gave a brief summary of the work of that body in controlling oil pollution, beginning in 1917. He stressed the cumulative effect of the oil in sewage discharged to bodies of water, and stated that through the efforts of Associated Sportsmen, ordinances to control waste oil had been passed in Oakland and San Francisco. The first notice to the commission was that oil reached Lake Merrit in Oakland and did considerable damage to ducks, which are a great attraction. A waste oil company operating in Oakland and San Francisco is at present collecting 60,000 gals. of waste oil per month. He considers this a good start and believes that by going after the large offenders first, most of the oil can be kept out of sewers.

Digestion of Activated Sludge

By F. H. Froehde*

In the September, 1929, 'California Citrograph', I read the following statements: "If the water now being rapidly transported to the ocean from our fast-growing cities could be purified and used for agricultural purposes, it would mean conservation of thousands of acre feet of water now permanently lost."

"Many technologists, scientists, and bacteriologists believe that this waste sewage water can be reclaimed and purified by modern, efficient methods. They state that after being processed, it will be chemically and bacterially as pure as it was before it was used for domestic purposes. There is no thought of this wastage being again used for domestic purposes; but if used for agriculture, it will materially increase the available water for domestic purposes."

Use of Sewage Water for Irrigation—At Pomona we had an idea of conserving water and selling it for irrigation purposes before we decided upon the type of sewage treatment plant to be built. An activated sludge plant was built in conjunction with an Imhoff tank, acting as a preliminary settling tank. We had also planned to use an Imhoff tank to digest the sludge from the activated sludge tank, pumping activated sludge into the digestion chambers of the Imhoff tank. This did not work out in practice.

To prove that the 'technologists, scientists, and bacteriologists' are right, I quote the following extracts from a Smith-Emery Co. report of an analysis of effluent, submitted without their knowledge of the source of the sample.

"From the standpoint of the mineral matter in the sample, this is a satisfactory water for drinking purposes and for other domestic purposes and for irrigation use."

"The presence of phosphoric anhydride in the amount of 0.55 per gal., indicates that the water should be more beneficial for irrigating purposes than the average water in the district. The nitrogen content of 1.27 gr. per gal. is high, and this would be of value in irrigation. It is indicated, however, that the water may

*City engineer, Pomona. Paper read by Alva J. Smith, of Black & Veach, Consulting Engineers, Los Angeles and Kansas City.

have been polluted by sewage, and may not be satisfactory for drinking purposes."

Analyzing the figures given in the report, I would further emphasize the value of this water for irrigation purposes. On the basis of 1.27 gr. of nitrogen per gal., and based upon a 24-hr. flow, the effluent is carrying away nearly 175 lb. of fertilizer per day. It is estimated that 50 lb. of horse manure is equivalent to 1 lb. of nitrogen in solution; so that by the production of

Pomona Sewage Treatment Plant

175 lb. of nitrogen, irrigators are obtaining the equivalent of 8750 lb. of horse manure per day. Of course, the humus of the horse manure is not obtainable in the effluent.

Realizing the possibilities of this effluent for irrigation purposes, the Northside Water Co. of Walnut, California, arranged for the use of this effluent. They agreed to pay one-half cent per inch-hour for the effluent during the six winter months (October to April), and one cent per inch-hour during the remaining six months of the year (April to October). The con-

tract is for a period of 20 years, and at the end of that period an adjustment is to be made, when, it is believed, the ranchers will realize the value of the effluent and the city can obtain a much higher rate.

The disposal plant is situated 1½ miles west of the city limits and, in order to use the effluent at Walnut, it was necessary for the Northside Water Co. to build a 21-in. pipe line 5 miles long, at a cost of $80,000.

Operating Costs—The revenue derived by Pomona from the sale of effluent and sludge in the fiscal year 1928-1929 was as follows:

Effluent	$4,669
Sludge	414
Total	$5,083

The sewage of Claremont and La Verne is also treated in the Pomona plant, and each of these cities contributed $694 toward the cost of operation. Adding this $1389 to the total given above, makes a grand total of $6472 for all receipts to be credited to plant operation.

In addition to these receipts, Pomona derives $1500 per year from the lease of the old sewer farm. For 2½ months each year, it is necessary to divert cannery wastes to the old sewer farm, where the solid matter is settled out in earth basins and the water is pumped onto a 100-acre farm. No water is permitted to escape from the farm into any of the adjoining 'dry' creeks. All costs of operating the sewer farm are borne by the lessee.

The waste water from a paper mill situated in the city of Pomona was another source of revenue last year, amounting to $1653. The waste water from the paper mill is taken down to the disposal plant in a separate line, into which no sewage or other industrial wastes are dumped. This water is then discharged into the pipe-line of the Northside Water Co. and mixed with effluent from the disposal plant. Considerable objection has been raised by the ranchers using this combined effluent, to the great amount of cellulose contained in the paper mill water. After much persuasion, we have succeeded in getting the paper mill to install Oliver filters which will be in operation by October, 1929.

The total receipts from all sources are $9624, as follows:

Sale of effluent (disposal plant)	$4,669
Sale of sludge (disposal plant)	414

Claremont and La Verne's contribution to disposal plant operation	$1,389
Sale of paper mill water	1,652
Lease of sewer farm	1,500

The total cost of disposal plant operation for the fiscal year 1928-1929, was $9112. Of this amount, over $1000 was spent for chlorine gas to chlorinate the effluent as required by the State Bureau of Sanitary Engineering.

To the disposal plant operation cost we credit only revenue derived from the sale of effluent and sludge. This brings down the net cost of sewage treatment to $15.04 per m.g. for the fiscal year 1928-29.

Perhaps we are not quite fair in our credits to the cost of disposal plant operation, and we have a higher net cost per m.g. than we actually should have. For example: When we by-pass the cannery wastes to the sewer farm, it is necessary to by-pass a large quantity of domestic sewage with these wastes, and consequently we have that much less effluent to sell from the disposal plant, with the same cost of operation. Upon checking over the figures of net cost of treatment per m.g., I found that in May, 1929, it was $0.944, but that in June, when we found it necessary to divert the cannery wastes together with domestic sewage, the cost jumped to $12.45, and in July it was $12.37 per m.g.

From the standpoint of operating cost, those concerns having trade wastes to dispose of should bear part of the charge for disposal.

Plant Experiences—We attempted to pump sludge from the activated sludge plant into the digestion chambers of the Imhoff tank. By experience it was found out that this would not work. The pumping of activated sludge into the digestion chambers of the Imhoff tank caused a heavy deposit of sludge to come up into the flowing-through chambers, completely destroying the action of the Imhoff tank. This caused a thick screen of sludge to flow on top of the liquid going into the activated sludge plant, and consequently again caused an excess of sludge in the activated sludge plant. The sludge from the activated sludge plant evidently is of a different quality from that of the Imhoff tank and consequently they will not mix.

Imhoff, upon a visit to our plant, asked me why we could not return the activated sludge to the digestion chambers of the Imhoff tank, as was being done in Germany. I replied that I did not know why not, unless the activated sludge in Germany was of different quality. Imhoff concluded that they could successfully

return activated sludge to the digestion chambers of an Imhoff tank, because they first diluted the activated sludge with water to facilitate pumping, and consequently it was much lighter than our sludge. Domestic water being at a premium at our disposal plant, we would find this to be a costly operation, so we have not resorted to this practice. Instead, we return the activated sludge to the inflow compartment of the Imhoff tank, where it is mixed with the raw sewage. This system is not entirely satisfactory, but we are obtaining fairly good results.

As the sludge increases in the activated sludge tank, we may overload the Imhoff tank by returning all of the activated sludge; but before that time arrives, we hope to have a separate sludge digestion chamber installed, which should solve our problem.

Conclusions—I believe that all sewage water in the southern part of the state should be conserved for agricultural purposes, thereby materially increasing the available water to be used for domestic purposes.

The activated sludge method of treating sewage produces a satisfactory effluent for irrigation purposes, but this method is, of course, the most expensive. But if it is necessary to spend from $150,000,000 to $400,000,000 to bring water to Southern California from the Colorado river, would it not be good business to conserve what water we already have at a cost of approximately two cents an inch-hour?

DISCUSSION

C. C. Kennedy cited an experience at the Montezuma plant confirming the findings that the addition of return activated sludge to the inflowing chamber is much more satisfactory than to put it in the digestor. He also reported that the returned sludge seemed to act as a coagulant and cause most of the scum to settle.

Alva Smith described tests on activated sludge made preliminary to the design of a separate sludge digestion tank at Pomona, which showed that after ten days' storage, 43% settled sludge remained at the bottom. The settled sludge could be discharged to the Imhoff tank and would remain settled, thus helping to do away with scum formation.

R. F. Goudey described the plant at Salem, Ohio, which he inspected during a recent trip East, consisting of separate sludge digestion with gas collection and heating, and digestion of activated sludge. When excess activated sludge was returned to the digestion tank it upset the entire treatment plant, because the

overflow water had too high a B.O.D. for the aeration tanks. This was overcome by installing a separate settling tank for the excess sludge, concentrating and pumping thickened activated sludge to the digestion tank. The overflow from the digestion tank was always clear thereafter, showing that the water content of the returned sludge had a great bearing on the character of the return liquor. He considered the same condition to exist at Pomona, with too much water in the returned activated sludge, and the proposed improvement there to be logical.

In response to a question by T. H. Haseltine, if the digestion tank had provision for removing liquor before activated sludge was pumped in, Goudey replied that it had not, only allowing clear water to overflow when sludge was added.

Separate Industrial Sewers and Chlorination at Tulare

By R. M. Berryhill*

The title of this paper seems to indicate that the sewage disposal problem at Tulare is different from that encountered elsewhere. But there can be little doubt that similar conditions are met with in any city situated as Tulare is in the heart of a large dairy section and having a number of large milk products plants within the city.

However, the solution of this problem in so far as it has been solved at Tulare, is perhaps somewhat unique, and I take it this is the subject assigned me.

A brief statement of our experience in arriving at the present method of disposal and the results obtained is probably the only treatment of the subject that will be of interest here.

Tulare has now a population of 7500. In 1910 when our first sewers were constructed, the population was but 3000, and the only industries were two small creameries, neither of which used the city sewers for waste disposal. The two Cameron septic tanks and an 80-acre farm then provided for disposal, operated very satisfactorily as long as domestic wastes only were treated.

In the year 1919, under pressure from residents of the city, the two creameries, both of which had grown considerably, and a new fruit canning plant, were connected to the city sewers, and trouble immediately followed. With the continued growth of these industries, and the water logging of the farm, it was only a short time until conditions became intolerable. In 1925, a conventional activated sludge plant was built on the site of the old plant, utilizing the Cameron septic tanks for presedimentation purposes in lieu of screening. This plant was designed for a flow of 500,000 gals. per day, but by the time it was put in operation the load had increased to 600,000 gals. per day, nearly half of which was a strong dairy waste. Results were, to say the least, disappointing. The dairy industry continued to grow until in the spring of 1928 the city sewers were receiving 800,000 gals. daily of strong waste from the various milk products plants, and conditions at the sewer farm grew constantly worse.

*City Manager.

Fortunately, at the time the activated sludge plant was constructed, storm sewers also were built throughout the city, with the main outfall at the sewer farm near the treatment works. After more than a year of experimenting with the activated sludge plant, it was decided to separate the industrial wastes from the domestic wastes by connecting the industrial plants to the storm sewers. This brought about an immediate improvement in the treatment of domestic wastes, demonstrating that the activated sludge plant would successfully treat ordinary sewage when not overloaded, and that we had only to solve the problem of dairy waste odor control. In the beginning, broad irrigation without treatment was attempted. This resulted in some improvement, especially during the winter months, but was still far from satisfactory.

In the meantime, at Wasco, the State Bureau of Sanitary Engineering tried chlorination in connection with broad irrigation, followed by thorough cultivation, as a means of meeting a condition quite similar to our own, and reported gratifying results.

Encouraged by these reports, the city of Tulare made arrangements with the Bureau of Sanitary Engineering to conduct a study of the problem; the city to pay the expenses, and the Bureau to furnish the personnel.

Work commenced in June and extended over a period of some three months, covering as complete a study of our entire sewage disposal problem as time permitted. This experimental work demonstrated that proper chlorination would sufficiently retard putrification of whey and other wastes contained in the water; provided the land be in such condition as to distribute evenly over the surface, and that the soil be thoroughly cultivated within 12 to 16 hours after irrigation. The experimental work also showed the domestic sewage could be spread upon the land without other treatment than passing it through the settling tanks to remove all settlable solids.

As this experience indicated a practical solution of a vexing problem, it was decided to continue the practice of operating separate sewers, and a W. & T. chlorinator with a capacity of 100 lb. per day was purchased.

Because of many complaints of odors escaping from catch basins along the storm sewer lines, this machine was set up in town rather than at the disposal plant. In the beginning chlorine was applied at the rate of 50 lbs. per day, which proved to be insufficient as the

weather grew warmer. After many trials, we found that from 8 a.m. to 5 p.m. the dosage should be applied at the rate of 75 lb. per day, and from 5 p.m. to 8 a.m. at the rate of 30 lb. per day.

As the activated sludge plant, which cost approximately $275 per month to operate, seemed no longer needed, the aeration units were shut down. The domestic sewage being passed through the preliminary clarifier, from which the settlable solids are removed daily and deposited in the separate sludge digestion chamber, and the settled sewage used for irrigation. Thus, we find that the cost of chlorination is offset by the saving in plant operation, the net result being, greatly improved conditions without increased cost.

However, there is still a fly in the ointment.

Experience during the past season has shown that in order to obtain the desired results in odor control, it is imperative that we either curtail our practice of cropping the farm or purchase more land.

As a large part of our disposal cost is paid for by the sale of farm products, and with a proper amount of land it is possible not only to pay all of such cost, but derive a profit as well, more land seems to be indicated as our next forward step.

Since properly financing the continuous growth of a plant of this kind by direct taxation is out of the question, and bond issues are slow and uncertain, we are now considering the advisability of levying a service charge for all sewer connections; thus, placing the operation and maintenance of our sewer system upon the same business basis as other public utilities.

DISCUSSION

In reply to a question by D. E. Perry, L. M. Berryhill stated that he had no record of the revenue the city received from industries, but knew it did not come near paying for their waste disposal. He could not see why cities should operate a water utility with charge and another utility (sewerage) free. However, if special charges are made on industries, they may move to other towns where no charge is made.

At the request of Leon B. Reynolds (president), C. G. Gillespie gave a statement regarding the sewer rental bill. It proposed an enabling act to allow municipalities or political subdivisions to levy a charge for sewer service. The legislators handling the bill did not favor the mode of operation, saying that sewer service like health service or education is something that could not be charged for on the basis of ability to pay,

for if that were in effect it would mean that poor people could not have education, health service, or sewerage. Gillespie added that the same argument might be made against making water supply a utility; but we know that all avail themselves of water service.

A. C. Beyer (Wallace & Tiernan Co. Inc.), discussed chlorination, saying that we are more and more beginning to think of chlorination as helping sewage disposal processes rather than solely as a disinfectant. The ton container is one of the things leading to this change. Chlorine is used for odor control in sewage plants as at Newport Beach and Ojai and creamery waste at Wasco and Tulare. Recently the Norton Creamery at Phoenix, Arizona, installed a chlorinator to control odors in connection with their waste disposal. Chlorination has also been used successfully to clear up clogged sprinkling filter beds.

Foaming and High-Rate Land Disposal

By L. H. Gadsby*

At Visalia we cannot claim much acquaintance with really severe foaming. The considerable width of the gas vents in our Imhoff tanks (4 ft.) is undoubtedly an important factor in saving us trouble from the accumulation of scum in the vents.

However, we are hardly justified in claiming that we have one of the few Imhoff tanks in existence which never presents this phenomenon of foaming. Scum has always accumulated in our gas vents, but it has seldom puffed up enough to force us to build up the freeboard of the tanks. Had our vents been narrower—say only 2 ft. wide—it is likely we would have found that the same quantity of scum forming would have made it difficult for the gas to escape freely, and active foaming would have occurred. As it is, we have removed considerable quantities of the scum about once a year, allowing it to dry and then burning it.

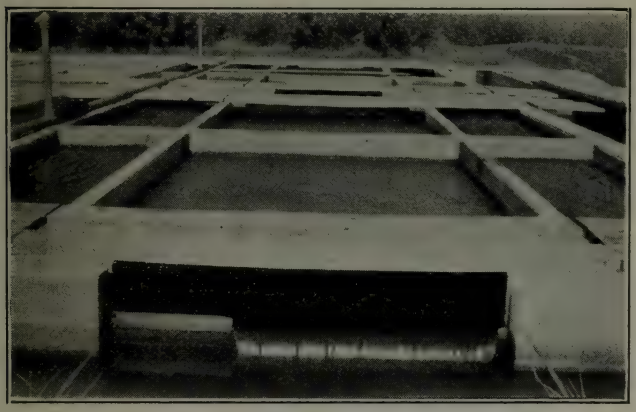
We have been somewhat mystified by the volume of scum that seems to accumulate in the vents; also it has been hard to understand its variation in volume and condition from time to time in the same tank, together with differences in behavior of the four tanks, all operating continuously on the same sewage. We were inclined to be unconvinced when we read authoritative statements to the effect that there should be comparatively little scum in the vents of an Imhoff tank that was operating properly. Going a step further, we learned that a somewhat acid condition of the tank was productive of increased scum. Therefore, a thick layer of scum such as we see in many Imhoff plants is quite a sure indication of an acid condition of the tank.

At the suggestion of C. G. Gillespie, chief of the State Bureau of Sanitary Engineering, we set aside one of our four tanks about a year ago, and drew no sludge from it for a long time. In fact, we have only drawn a little sludge once or twice from this particular tank, when the sludge compartment became about full. This experiment was expected to demonstrate that the accumulation of a large proportion of well-ripened sludge in the tank would overcome its acid condition

*City Engineer, Visalia.

and result in more normal operation. We have watched this tank carefully, especially during this past summer, and the experiment is proving successful; the tank usually testing close to neutral and sometimes a little better; the scum has been noticeably less in quantity than on the other tanks, and it also has usually been of a consistency that allowed gas to escape readily through it, in spite of considerable waste oil in the sewage.

It is probable that a system of piping that would enable us to agitate the sludge and interchange sludge from one tank to another, would be distinctly useful, and we could thereby improve more rapidly condi-



Imhoff Tanks at Visalia Sewage Treatment Plant

tions in the tanks that are not up to normal operation.

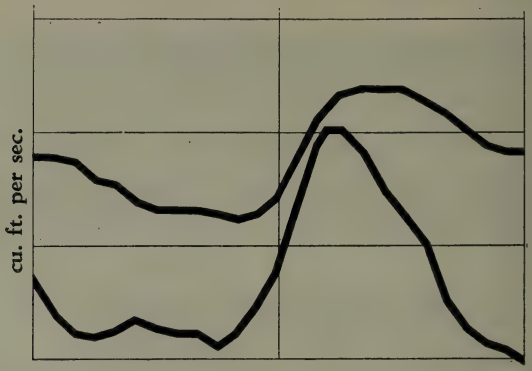
In disposing of sewage on land, one important matter to be considered is: How much water will the land handle? Of course, in case crops are to be raised, the water must be applied in such a way and at such times that the crops will not be damaged.

At Visalia, the city owns a 160-acre farm, about 120 acres of which is now checked and leveled so that it can be irrigated by the effluent from our sewage plant. The principal crops raised are alfalfa and Egyptian corn; and the land varies somewhat, being largely a sandy loam but with some soil of a heavier, clayey nature.

By means of a weir and a recording gauge in the influent channel we get a continuous record of the amount of sewage we have to handle. We do not know whether we are applying water at a much greater rate than other sewage disposal plants, but we have worked out some figures that may be of interest.

In 1925, during the calendar year we applied 1114 ac. ft., or the equivalent of 6.96 ft. depth on each of the 160 acres. Assuming that we only cultivated and irrigated about 120 acres we applied nearly 9.2 ft. of water per acre.

I have here a chart showing typical daily flow curves. The higher curve, in the heavy black line, is the flow on August 18, 1928, midnight to midnight, being in a period when the local peach canneries were running and we were carrying our heaviest load. The flow for this day averaged 3.32 c.f.s. or 6.58 ac. ft.; or 2,144,000 gal. If this flow was maintained through the year, we would cover our 160 acres with more than a



Upper line—August 18, 1928;
Average Q=3.32 cu. ft. per sec.
Lower line—August 8, 1929;
Average Q=2.14 cu. ft. per sec.
Depth on 160 acres for 365 days=4.84 ft.;
Depth on 120 acres for 365 days=6.45 ft.

foot of water each month. Using only 120 acres, we would be disposing of more than 1.5 ft. each month on each acre.

The lower curve (above) is a day this summer, Aug. 8, 1929, when the peach canneries were not operating. In fact, our canneries were not operated at all this summer, due to extraordinary conditions in the peach industry. However, this day is rather typical of our ordinary flow of sewage, both winter and summer. The curve shows an average flow of 2.14 c.f.s., which means 4.24 ac. ft. for the day, or about 1,381,000 gal. If we assumed this to be an average day for the entire year, we would have to care for 1550 ac. ft., or an average on the 120 acres of nearly 13 ft. However, I do not believe the actual figure will prove to be quite this much, although it will undoubtedly be considerably higher than the 9.2-ft. depth we had in 1925.

DISCUSSION

W. F. Rantsma asked what maximum rate of land filtration was estimated at Visalia, stating that at Fresno, with beds of 5 acres each, 15 million gallons daily is handled on 400 acres and they believe by using greater depths 200 acres would be enough for land filtration. Gadsby replied that the Visalia sewer farm was used as a farm, not for land filtration alone as at Fresno. Commercial crops are raised, usually Egyptian corn and alfalfa, using 8 to 12 ft. of water yearly, where ordinarily ½ to 2½ ft. would be enough. With sandy soils as much as 20 ft. might be used.

High-Rate Land Disposal

By F. J. Rossi*

This paper describes briefly my experience with high-rate land disposal while making a study of the sewage disposal problem at Modesto. Like many other cities, Modesto has greatly neglected its sewage treatment plant and had no one directly in charge of its operation. It is my belief that it is not always the governing body of a municipality that retards the installation or expansion of a treatment plant, but the inability of the parties in charge to stress the necessity for a treatment plant for the safety of its inhabitants. The city council and myself thoroughly went into this problem and decided that something must be done, as it was unfair to the general public and dangerous to empty the effluent into the river although it had gone through a septic tank. First, the city council appropriated funds to be used for experimental purposes. On account of the topography of the land, the high-rate land disposal method was selected for experimental purposes.

Soil Formation—In order to find out what type of soil existed from the surface to a depth of 18 ft., test wells were drilled at intervals of 100 ft. on the land to be used. The first 6 to 12 in. is fairly heavy sandy loam; from 1 to 12 ft. a light sandy loam, which resembles quicksand when wet; from 12 to 15 ft., fine sand with a trace of blue clay; at 15 to 18 ft., fine and coarse sand with some quicksand. About 3 ft. of water stood in the bottom of four wells, the fifth well being wet sand. I felt it was not necessary to go any deeper as water in the river stood at 18 ft. below the surface of the lowest filter bed. The soil formation encountered in the five test wells was practically the same.

Design of Experimental Units—Unit No. 1. The first unit is rectangular in shape, 147.3 by 390.8 ft., and contains 42,827.5 sq. ft. The levee is 3 ft. high; the soil being sandy loam. About 50 ft. of 6 in. open joint tile was also placed in the bed, 4 ft. deep, and carried through the levee to determine drainage in the soil.

The sewage was first passed through the septic tank to remove the solids, and then into the filter bed to a depth of 2 ft. A gauge was placed in the bed to keep

*City Engineer, Modesto.

a close record of the hourly subsidence and determine the amount of sewage filtered into the soil. The first filling, as gauged over a 2-ft. weir, amounted to 11,243 cu. ft.; the capacity of the bed at a depth of 2 ft. being 85,655 cu. ft. This showed that the amount filtering away during the filling period of 13 hours was 26,799 cu. ft., or at the rate of 0.77 in. per hour. A check on the underdrain at this time showed no signs of moisture, but considerable air came out of the tile. The air was perhaps caused by the settling of the loose dry dirt in the trench. No air was noticeable after filling the bed three times.

Ten continuous applications were applied, and after the third, the remaining seven averaged a drop in depth to ½ in. per hr., or 1784.4 cu. ft. per hour, or 42,826.5 cu. ft. per day, this being equal to 43,560 cu. ft. or 326,700 gal. per acre per day. Although only ten applications were applied, it is my belief that approximately the same results will continue as the site is adjacent to the river and between 10 and 18 ft. above water level most of the year.

Unit No. 2. The second type was a strip check 20 by 448 ft., the last 48 ft. being used as an overflow reservoir. The strip was levelled to a grade of one tenth of one per cent. The effluent was admitted at the rate of 20 cu. ft. per min., or 139,392 cu. ft. per acre per day, measured over a 20 ft. weir. The water traveled the first 100 ft. in 25 min., the fourth in 80 min. The total time to travel 400 ft. was 2 hrs. and 50 min. This rate of flow was continued for 8 hrs. each day, and upon the third day approximately the same results as above were maintained. The reason for such high rate disposal may be due to a very thin film of water running over the check at the same time, and heated by the sun rays causing a large amount of evaporation.

Although this method is 3.2 times as effective, it has its disadvantages. First, results in the winter months may not be very effective, and even in the summer months after it has been in continuous operation for some time. Second, the check must be kept to a true, even grade to prevent washing small ditches along the check. Third, plowing up the check would be difficult, as distributing weirs must be placed at least every 100 ft. Fourth, it requires constant care 24 hours per day. This method should prove out well on land that is level and more suitably adapted. After compiling all the data and summing up their merits, the type as stated in Unit No. 1 was selected. This, to my view, will prove more satisfactory for this particular prob-

lem. By this, I do not wish to convey the idea that strip check and the shallow flow method is not good. I would like to see more experiments carried on with this type of disposal, as I am convinced it can be used to good advantage in suitable locations.

Beds No. 1 and 2 were not cultivated during these experiments. However, this will be done to keep down weed growth and no doubt help keep the soil porous and produce better results.

Costs—The cost of Unit No. 1, comprising approximately one acre, being half cut and half fill, was $272. The cost of Unit No. 2 was $176. This is exceptionally high, due to large cuts and fills and considerable hand trimming. I would not consider this an average cost of strip checking, as more even land could be strip checked for much less.

After completing the various experiments as approved by the city council, it was decided to install a clarifier and use the existing septic tank as a temporary sludge digester. The effluent from the clarifier will be drained into the bed as described under Unit No. 2. Sufficient beds will be constructed to take care of the liquid, and at the same time have two or three days to dry before refilling. Upon my recommendation, the city council appropriated funds to carry out this plan.

At present additional beds are being prepared, and plans are being prepared for the clarifier and remodeling of the old septic tank to operate in conjunctiou with the system as above stated.

The matter of experiments on high rate land disposal was discussed with C. G. Gillespie and his assistant, E. A. Reinke, of the State Board of Health, and I am glad to say that their interest and cooperation in this work helped me carry on this experiment which has proved of value to the city of Modesto.

From my experience, I would say that a municipality should appropriate funds for experimental purposes on the proposed site before making a final selection of the type of disposal plant that will be best suited both from an economical and efficient standpoint.

DISCUSSION

John Mason discussed the overflow arrangement (not mentioned in the paper) to prevent washing of beds if they should overflow. Rossi stated the work had been done after the paper was written. If the workmen are not on the job, the beds take the overflow anyway and the last overflow will run directly to

the river.

C. G. Gillespie remarked that at Pasadena the rates per acre per day were 10,000 gal., at Visalia, 15,000 gal., at San Luis Obispo, 20,000 gal.; in all cases crops being raised: at Fresno, 60,000 gal. on land with no cropping; at Modesto, 360,000 to 750,000 gal., and at Kingsburg, sprinkling filter effluent on sand at 750,000 gal. The Carmel sand beds operate at a rate of 1,500,000 gal. These figures show the range of possibility of ground taking up sewage, the rates for simply getting rid of sewage being much higher than those given in the text books, on the basis of oxidized result in the percolated water.

Imhoff Tanks at Stockton

Plant Described—Problems of Operation—Costs

By W. B. Hogan*

In 1922, the city of Stockton put into operation a two-unit Imhoff tank at the 'South Sewage Disposal Plant'. This plant was designed by Fred H. Tibbetts, consulting engineer, of San Francisco, and constructed under my supervision.

The plant serves an area of 4½ sq. mi., primarily residential, which represents one-half of the city area; the tributary population is 20,000. There are, however, a number of industrial plants—canneries, foundries, manufacturing establishments, and laundries — tributary to the plant. The cost of the plant, including pump house, tanks, levee enclosure for flood protection, water supply, and other accessories, was $103,000.

Tank Descriptions—The tanks are regular in shape, 57 by 28½ ft. The flowing-through chambers are 9 ft. wide, 55 ft. long, and 14½ ft. deep. The vent area is 26.1% of the total area, excluding concrete walls.

The four sludge digestion chambers are shaped as the inverted frustrum of a cone. There are two interconnected chambers in each tank, with a total plant capacity of 20,918 cu. ft., or about 1 cu. ft. per connected capita.

Raw Sewage Flow—The average distance from the center of the collection area to the disposal works is 3½ miles, and the average rate of flow is 2 ft. per sec., the average time required for the sewage to reach the disposal works being 2½ hours. The outfall main leading to the plant is a 36-in. diam. reinforced concrete pipe, and the flow line at the disposal plant is 16½ ft. below the general ground level. Sewage reaches the disposal works in a fresh condition, with little or no hydrogen sulphide gas.

Sewage enters the pump station and flows into a small sump or chamber, connected with 8-, 10-, and 12-in. American Well Works open-runner sewage pumps. The pumps are driven by 25-, 50-, and 75-hp. vertical motors, respectively. Approximately 85% of the total flow is pumped by the 8-in. unit, the 10-in. pump being operated only for peak loads and in emergencies. The 12-in. unit is likewise emergency and

*City Manager and former City Engineer.

standby equipment. It is operated only when a large quantity of storm water enters the sanitary system through the old buildings in the business district and storm water catchbasins connected with the sanitary sewer system.

Stockton Sewage Treatment Plant

Disposal—The sewage is lifted by pumps against a maximum head, including friction, of 35 ft., to Imhoff

tanks situated 30 ft. outside of the pumping station. The piping system leading to the tanks is so arranged that the flow can be turned in at either end. Under present operating conditions, the flow through the tanks is reversed on an average of once a week. This accomplishes a more uniform distribution of settleable solids in the digestion chambers and prevents piling up of sludge.

The velocity on the flowing-through chambers is dependent upon the number of pumps operating at one time. The average retention period is small in comparison with many earlier installations of Imhoff tanks in the United States and Europe, at Stockton being not over 30 minutes for 85% of the sewage handled.

No recent tests have been made to determine the percentage of solids removed by sedimentation, but I am confident that the removal is not less than 85% of the settleable solids. Tank effluent flows by gravity over a weir and then through a 12-in. cast-iron main to a venturi meter in the pump house. From here it flows through a 36-in. diam. concrete pipe to the San Joaquin river, a distance of 800 ft.

The San Joaquin river averages 10 ft. below the sewage level in the Imhoff tanks and it is possible to constantly maintain a gravity flow, except during extreme floods. The piping is so arranged that discharge of sewage during flood periods can be made directly into the river, without passing through the tanks.

Foaming—When the tanks were put into operation, violent foaming took place. This was controlled by hosing down the vents with fresh water, under a 10 to 15-lb. pressure. Foaming has never ceased but, as the condition is no longer violent, it causes little trouble. This foaming seems to bear a direct relation to atmospheric conditions, as it occurs principally during winter months. Foaming was reported between January 23-29 and October 1-December 28, 1926; January 1-February 23 and November 28-December 31, 1927; and January 1-March 22 and December 15-31, 1928. During the past four years, the Stockton tanks have foamed on an average of 104 days per year.

Where Imhoff tanks receive proper attention and an operator is always on duty, the control of foaming is merely an incident in the day's work.

From observation of our tank operation, I believe that a greater vent chamber area should be provided and that the sludge digestion chambers should have larger capacity. Otherwise, supplementary digestion tanks should be built alongside and the sludge pumped

from the bottom of the present chambers into the top of the supplementary digestors and then returned by gravity from the bottom of these digestors to the present sludge chambers. In this event, our Imhoff tanks would be used primarily for sedimentation purposes and ripening sludge for seeding the supplementary digestion tanks.

Handling Sludge—The Stockton sludge is not fully digested, as it contains small pieces of paper and will burn readily when dry. This is because the amount of sewage makes it necessary to draw off sludge in three or four-week periods. Although this prevents sludge from rising into the flowing-through chambers, it does not give time for complete digestion. In our case, the condition is not serious, as the sludge is digested sufficiently so that it will dry rapidly during the summer and fall months. This sludge does not give off disagreeable odors. In the winter, due to fogs, rain, cold and damp weather, it is not possible to dry the sludge. Disposal during this period is accomplished by running the sludge into deep borrow pits excavated during the levee construction. As the levee is 12 ft. high, ample room is available in the borrow pits. No fermentation or disagreeable odors have occurred from depositing sludge in the borrow pits.

During the spring, summer, and fall months, sludge is dried upon a bed, 65 by 120 ft., underdrained with sand, fine and coarse rock, and tile. The drying period is dependent upon atmospheric conditions but is ordinarily one week. Dry sludge is removed from the beds by forking into a wagon and is then hauled to low ground surrounding the plant.

Cost Data—Operating costs have been kept on the Stockton tanks for seven years, with averages for the period as follows:

Total yearly operating expenses	$11,765
Total yearly expenditure, including operating costs and improvements	$12,030
Yearly sewage flow in millions of gallons	482.41
Daily flow in millions of gallons	1.33
Yearly cost of handling sewage, per million gallons	$24.84
Cost for power, per million gallons	$6.27

DISCUSSION

F. E. De Martini reported an experience at Morgan Hill where foaming and acid condition of the scum was troublesome and produced odors. The remedy was to get rid of the sludge and add 200 lb. of lime to the gas vents. The new sludge is a good deal better than

the old.

C. C. Kennedy, consulting engineer, San Francisco, stated that the Morgan Hill plant, which he designed, operated 5 or 6 years without difficulty. The condition which De Martini mentioned, developed in February and was reported in July. No biologic action was going on and it was intensely acid—pH 5.4. Dosing with lime made foaming worse than ever, at first, but it is steadily improving. The original cause was not determined, but he thought the discharge of large amounts of waste acid from a battery plant may have been the start of the trouble.

Gas Burning and Chlorination

By F. S. Currie*

Most of my experience with the collection and burning of gas and the use of chlorine for odor control has been gained in the operation of the San Bernardino plant. The location of this plant was such that it was necessary to use all possible means to control odors. At the time this plant was designed, it was hard to tell from the data available the most economical point at which chlorine could be introduced; however, as the design of the plant included a 6300-ft. inverted siphon, I believed that provision for chlorination should be made at the upper end of the siphon line. This left only two other possible points to pre-chlorinate the sewage; one at the immediate entrance to the plant and the other at the dosing chambers. Chlorination at all points is made through the use of Wallace & Tiernan vacuum type chlorinators.

The chlorinating equipment at the upper end of the inverted siphon lines consists of a concrete building about 6 ft. square, with barred windows and a metal door with a Yale lock, it being my opinion that a chlorinating house situated in such a place as to arouse the curiosity of small boys and others should be so constructed that entrance is impossible. Directly in front, and so constructed that the top is flush with the ground, is a concrete pit 4 by 10 ft. and 4 ft. deep. This pit has a hinged steel-cover provided with a padlock. On the floor of the pit is a scale platform, the beam of which is in the house proper. This pit is of such size as to accommodate a one-ton chlorine container. The chlorinating equipment consists of one 300-lb. machine.

Chlorination at the plant is accomplished with two 200-lb. and one 300-lb. chlorinators. The State Board of Health required that facilities for final chlorination be in duplicate. These chlorine machines are on the second floor of the control house. The scales, of which there are two, are on the first floor. Facilities have been provided for the storing of 18 tons of chlorine in the storage room adjacent to the scale platform. Overhead tram-rail lines and hoisting equipment have been provided so that one man, if necessary, can replace the empty containers.

*Consulting Engineer, Los Angeles and San Bernardino, and designer of San Bernardino plant.

All containers are stored horizontally and are placed in a like position on the scales; however, I believe that considerable room would be saved by standing them on end not only on the scales but in the storage room. The outlets of the two 200-lb. machines are so arranged and controlled through hard rubber valves that one or both may be used for final chlorination or for chlorinating the effluent from the Imhoff tanks at the entrance to both of the dosing chambers. The 300-lb. machine discharges directly into the incoming sewage at the bottom of the riser stack, which is about 20 ft. in depth. It is interesting to note that though the sewage is chlorinated at the rate of approximately 4 p.p.m. at the upper end of the siphon, a dosage in excess of 6 p.p.m. at the bottom of the stack showed no color with orthotolidine at the top of the stack.

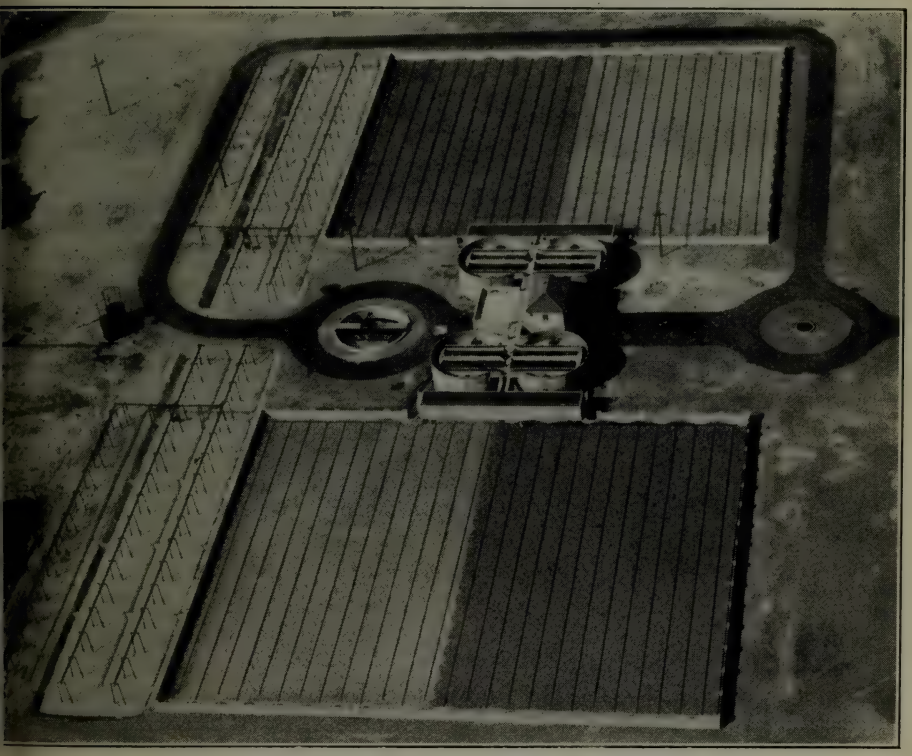
However, no trace of hydrogen sulphide could be found except at the outlet of the Imhoff tanks, which can be easily controlled by the addition of chlorine in the dosing chambers. As yet it is hard to state whether it would be more economical to chlorinate at the upper end of the siphon or at the immediate entrance to the plant. I believe the best results are obtained by chlorinating at both points.

Chlorination at the dosing chambers is at best a very ticklish job. I believe that chlorination at this point is very necessary and can be carried on without detriment to the life in the beds if great care is taken to increase the dose gradually until the amount desired is reached. We experienced a considerable unloading of the beds by starting in with a too heavy dosing. It is also necessary to watch the chlorinating machines very carefully as they are apt to vary considerably from the amount for which they are set.

When the plant was first put in operation, we chlorinated the final effluent in such quantities as to produce from 0.2 p.p.m. excess at the creek, which is 1500 ft. below the point of application. Within a short time, local newspapers, in large headlines, stated that thousands of trout were being killed in Warm creek by the poison chemicals and raw sewage, and that the local chapter of the Isaac Walton League had filed complaints with the State Fish and Game Commission. The report was greatly exaggerated as investigation by the Fish and Game Commission disclosed.

Tests carried on by the Fish and Game Commission may be of interest. At the time we were running 0.2 to 0.3 p.p.m. excess of chlorine, representatives of the Commission planted 18 trout in live traps in the

stream at three points: one in the effluent before dilution with the creek water, one in the main channel 25 ft. below the outlet, and one 500 ft. below the outlet. The trout in the effluent lived 9 hours, those 25 ft. below the outlet 18 hours, and those 500 ft. below were in no way effected. These trout, which were about 3 in. long, were brought from the cold water of the Rainbow Angling Club and were undoubtedly weakened somewhat by the warmer waters of Warm creek. The



Airplane view of San Bernardino Sewage Treatment Plant

dilution in the creek is 8 to 1. Final chlorination has been decreased to produce only 0.1 p.p.m. in excess and no more complaints have been received.

In the first six months of operation sufficient chlorine has been added to control all odors and in that time the plant used 41,694 lb. of chlorine, 9400 lb. of which has been applied at the upper end of the siphon lines. In that time over 700,000,000 gal. of sewage has been treated at the plant, and the total dose averages only 7.2 p.p.m.

The contract construction price of the plant in-

cluded the furnishing of 18 tons of chlorine and the outright purchase of the 18 containers. As we expected to use a considerable amount, we were naturally anxious to secure as low a price as possible and wrote to several chlorine manufacturers both on the West Coast and in the East. The Electro Bleaching Gas Co. of Niagara Falls, New York, offered the chlorine shipped to us at $5.53 per 100 lbs. This was considerably lower than the prevailing price at that time; however, this price has been met and since lowered by western manufacturers.

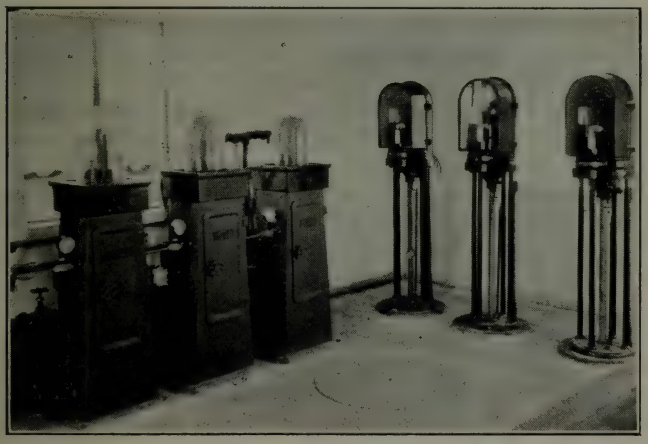
Probably the most important item in the control of odors at the plant is the provision for the collection and disposal of all gases produced by the digestion of the solids in the Imhoff tanks. In general the gas vent areas of the Imhoff tanks have been covered. The gas is collected and stored in two 750 cu. ft., lift type, gas holders under a pressure of about 6 in. of water. Such gas as is necessary is utilized in a 40-hp. gas engine direct connected to an electric generator. All excess gas is burned in the rear of the plant.

The gas vent areas, in the circular Imhoff tanks, are sectors of circles, and as each unit consists of two tanks, it was necessary to provide gas collection for eight separate sectors. Each collector consists of a casting covering a 4-ft. circular opening in the concrete cover of the gas vent area. Through the center of the casting is a vertical shaft provided with a large hand wheel and a specially designed revolving rake so arranged that the floating sludge directly under the casting is broken up and pushed down. The casting is set at such an elevation as to be about 6 in. lower than the normal water level in the tank. Each collector is provided with a 6-in. cast iron drain with the necessary gate valves, and at two points opposite this drain, water connections have been provided so that excess sludge may be washed directly to the drain line. Especial attention is called to this drain, as it plays an important part in the proper functioning of the gas collectors. These drains should be used daily in order to prevent the formation of the heavy scum blanket, as a heavy scum is practically impossible to soften and remove if allowed to form. The casting itself is provided with a 2-ft. diam. cast-iron dome set free in an artificial water seal, in which the pressure may be varied from 6 to 10 inches.

The operators are instructed to turn the hand wheel two or three times daily and to run a small amount of fresh water into each collector. We have found, how-

ever, that if the flow into the tanks is not reversed at least every 3 or 4 weeks, the wheel will be hard to turn on the two collectors near the inlet, but that after reversing the flow, the floating solids seem to soften within a short time.

As a safety valve, in case the dry, hardened, floating solids choke the collection dome, we have provided a 3-in. vertical pipe extending through the concrete cover to a depth of 4 ft., so that should the volume of the gas increase to such an extent as to force the water level below the bottom of the pipe the pressure will immediately be released. In order to prevent explosion caused by backfiring through the lines, 3 water



Three Wallace & Tiernan Chlorinators at San Bernardino Sewage Treatment Plant

seals have been provided. These seals consist of an iron receptacle with tight cover and a glass water gauge, and so designed that the inlet pipe extends to within 6 in. of the bottom, the outlet being at the top. The elevation of the bottom of the inlet pipe is marked on the glass. The elevation of the water in the trap is kept about ½ in. above the mark, so that in case of back-fire, water will be forced into the inlet line. There is one water seal between the junction of the collecting lines and the gas holders, one between the gas holder and the burner, and one between the gas holder and the engine. I do not believe that water seals are necessary after all of the air has been expelled from the system, as the gas itself is non-combustible. The lift-type holders are an item in keeping air from the lines, for should a leak occur the holders will gradually drop and maintain a constant positive pressure for a considerable time.

The power end of the system consists of a 40-hp., 4 cylinder, Hercules engine direct connected to a 28 kva., 220-volt, 50-cycle, 3-phase electric generator, designed to operate at 1000 r.p.m. The generator is equipped with the necessary direct-current exciter and voltage regulator.

So far, no accurate tests have been made to determine the composition of the gas. However, we have been told by gas engineers that it must contain from 70 to 85% methane, the remainder being carbon monoxide, CO_2, nitrogen, and hydrogen sulphide.

Sewage was turned into the plant about the first of February, 1929. No gas was noticed for at least 30 days, but from then on until the first of June, gas production increased gradually to 1500 cu. ft. per day. During the latter part of June we experienced our first hot weather, gas production increasing within a week to over 5000 cu. ft. per day and by the second week to nearly 10,000 cu. ft. Foaming accompanied this large increase, and while liming had some effect at the start, conditions were so bad that sludging of the entire plant was resorted to. Considerable unripe sludge was dumped, and within two weeks all foaming had stopped even though the gas production had not dropped.

At present the generator is used only in the morning, which is the time of the greatest load, washing around the plant, skimming of the tanks, and pumping of the sludge being done at this time; but power demand at the plant is not a great item. The biggest load is the 15 hp. motor on the deep well pump for the water supply. Water is pumped from a 150-ft. well direct to a 4000-gal. hydro-pneumatic tank operating at pressures between 45 and 90 lb. There is also a 7½-hp. motor driving a Barnes sludge pump used for the removal of sludge from the secondary clarification tank. These two motors together with two 1-hp. motors on the skimmers and a 3-hp. motor on the clarifying equipment in the secondary tank, comprise the power consumption of the plant. The lighting load includes three 500-c.p. flood lights together with the various lights in the control house.

Production of power from the gas is not as yet on a paying basis, at least it has not proved so with our light intermittent demand. However, we plan to determine the total power that will be possible to develop, hoping to use this power to pump the effluent of the plant to a level above the city for irrigation use, and

then allow it to settle into the natural underground basin to supplement the domestic water supply.

I believe that the control of odors surrounding sewage treatment plants by the use of chlorine and the burning of all gases, is one of the important phases of sewage treatment; as the progress of modern purification of sewage is dependent on the tax payer, and until we, as engineers, can design practically odorless treatment plants, the layman will not sanction or finance their construction.

DISCUSSION

A. M. Kivari (The Dorr Company), said that practically all new separate digestion plants are adopting gas collection and heating, to reduce the size of the digestion tank and save money. Antigo, Wisconsin, and Salem, Ohio, are arranged so that gas can be used to burn material from the bar screens. At Salem, a Simmons type rubbish incinerator is used without odor trouble and all the operator has to do is remove ashes once a week. The gas has 700 to 750 b.t.u., and burns with a blue flame. He does not think we will see many more digestion tanks without gas collection.

Cost Keeping

By A. K. Warren*

It is somewhat inappropriate to present a paper on the subject of cost keeping since a special committee of the Association has been appointed to study various methods and to make recommendations for a standard that could be adopted.

Numerous papers on the subject have appeared recently. The eastern Sewage Works Associations are interested. The last issue of the 'Sewage Works Journal' carries a paper by C. E. Keefer, on 'Cost Data at the Baltimore Sewage Works', and a paper by Gus H. Radebaugh, 'Standardization of Costs in Sewage Treatment Works Operation', which was read at the second annual meeting of the Central States Sewage Works Association in June. An exhaustive article by Walter F. Freeborn appeared in the 'Surveyor and Municipal & County Engineer', of July 12, 1929.

Freeborn's paper is complete, giving forms of all accounts kept, and except for the terms, designations, and divisions of cost, compares with that of a large manufacturing plant with several self-contained divisions, including accounting on work incidental to the operation of the plant, such as machine shop and work shop costs.

The cost accounting of a sewage works or sewer system is essentially the same as for any manufacturing plant. The value lies in its ability to provide a reliable basis for comparing unit costs, and as a gauge to the efficiency and relative value of different processes and machines. The proper use of cost figures is quite as important as their proper compilation, and the relationship of costs to results cannot be overlooked.

The ordinary municipal accounting system, while satisfactory for its particular purpose, does not provide a complete cost system as herein considered, and it is almost imperative that one entirely apart from the regular accounting system of the municipality be carried out. It should be separate and independent for the specific purpose of showing detailed costs in connection with the plant and system, but in no way should it encroach upon, or attempt to modify,

*Chief Engineer Los Angeles County Sanitation Districts.

the regular bookkeeping and accounting of the municipality.

The prime requisite of a satisfactory cost accounting is the truth of its figures. By this I do not mean the truthfulness of the individuals using the system, but that the figures be so set out as to give the story completely and definitely. This may be made clear by quoting two paragraphs from a letter by A. M. Rawn, assistant chief engineer of the Los Angeles Sanitation Districts, to the chairman of the committee on cost keeping:

> "Two features stand out clearly to me as being vital, both to the continued successful operation of a sewage treatment plant and as a guide in future design. First, the cost of operation as related to flow and other conditions at the plant site, and second, the simplest possible adequate record of the plant chemistry and biology. The two are, to some extent, related and one will reflect conditions in the other, and the success or failure in plant operation can only be judged by comparative analysis of both.
>
> "As to cost of operation, this is apparently too many times misinformation. Sometimes it appears to be deliberate, and other times misapprehension of another's statement or effort. In my opinion, there is nothing to conceal in the cost of operation, and the only way an intelligent opinion can be formed is by a detailed inspection of cost. Also, an inspection of the results achieved with the type of plant in operation. Plant costs should be set out so that one can judge whether or not there is included in the item the features which should be there, that is: field cost; field cost plus field engineering; and field cost plus engineering, central administration overhead, depreciation on the investment and interest charges."

To be of practical value, the cost accounting must include all costs and charges whether they be direct or indirect, properly segregated to their particular phase or function of the works.

Differentiation should be made between purely operating costs and charges for investigations or experiments, which are really incidental to design, and properly a construction cost.

Freeborn points out the desirability of carrying depreciation accounts and making annual depreciation charges for capital expenditures in lieu of loan

redemptions and interest charges. Interest charges on one plant may be at a maximum, while on another plant loans may have been retired. In the latter case, the interest cost is not actual, but nevertheless the investment remains. For cost keeping purposes, the plant should be charged with the full rate of interest and depreciation.

Los Angeles County Sanitation Districts

COST REPORT OF JOINT DISPOSAL PLANT

ACCOUNT No. Unit Item — Month of 19

Original Cost in place = $

Cost in place to 19 = $
Additional costs for Month of = $
Total Cost in place to 19 = $
Total depreciation to date = $
Remaining value in plant = $
Estimated life = Years
Monthly depreciation of Total Cost = % = $

DETAILED COSTS

1—POWER:
KWH at ¢ per KWH = $

2—OPERATION—LABOR:
Direct charges = $
Proportional charges = _____ = $

3—OPERATION—MATERIAL & SUPPLIES:
Direct charges = $
Proportional charges = _____ = $

4—REPAIRS AND MINOR ADDITIONS:
Labor = $
Material = _____ = $

5—WATER:
Proportional part of Unit No. 100 = $

6—TRANSPORTATION:
Direct charges = $
Proportional charges = _____ = $

7—

8—

9—

10—

SUB-TOTAL $

QUANTITY FOR UNIT COST = M. G.
COST PER M. G. $

11—FIELD OFFICE CHARGES = $

12—GENERAL OFFICE CHARGES = _____

SUB-TOTAL $

COST PER M. G. $

13—DEPRECIATION = $

TOTAL COST =

COST PER M. G. $

Each function of the County Sanitation Districts' plant is segregated into units, which are further subdivided as to the particular piece of equipment or machinery. Distribution is made of the power, labor, material and supplies, repairs, water, and transportation to each unit. Labor is divided into direct and proportional charges, that is, work performed specifi-

cally on any unit, and the proportional charges of general work done on the plant. The total gives purely operating costs. Overhead and depreciation are added to give total costs, such as operation plus overhead, and operation plus overhead plus depreciation. All of this is summarized to give, at a glance, the total cost for each unit. Another summary gives a monthly total of the various charges or services, such as power, labor, material. At the end of the year, the monthly costs are summarized to give a yearly total. All costs are broken down into cost per m. g. Appropriate distribution sheets are used for distributing the expenditures, as they arise, to the proper unit and purpose.

In the case of the Sanitation Districts, all work done, and the expenditures therefor, are from funds raised for the purpose of sewage disposal. No work can be performed by another department without charge, as in the case of municipal works where the street department or park department sometimes does certain work for the sewage disposal plant without its cost being charged to the plant. Thus, the Sanitation Districts are assured of knowing the total cost.

A standard system should be flexible so that it may be applied with equal ease for a large plant using intricate methods, or a small one of simple operation. The principle would remain the same, however, and items not applicable need not be considered. The Sanitation Districts' plant and cost system is not as elaborate as the one described by Freeborn, yet the principle is the same. A sample of the unit summary sheet is attached. Details of supplying the necessary information to the cost accountant and for purposes of record can be worked out to suit individual needs.

In working out a standard method of cost accounting it is hoped that the committee will take into account the advantage of interchange of cost records with other parts of the country. Instead of the Association adopting a standard form directly, it may be advisable to have the Federation appoint a national committee to develop a standardized code of cost accounting out of material suggestions and records to be provided by each of the separate associations. This was suggested at the second annual meeting of the Central States Association, held at Indianapolis on June 21, by Radebaugh, and the following motion by Hansen was unanimously adopted:

'That the executive committee begin at once to arrange a national committee to follow out the recommendations in Radebaugh's paper, namely: that this organization recommend to the officials of the Federation of Sewage Works Associations that a national committee be developed to standardize a national code of accounting adaptable to sewage treatment works operation, which will make possible standard construction and operation cost for such projects; and that this committee meet with the view of advising on ways and means of obtaining accurate cost data."

Fly Control at Sewage Treatment Plants

By W. B. HERMS*

Flies of many species are attracted from far and wide to sewage, partly because of food but particularly because of the excellent pabulum it furnishes for the development of fly larvae. Under favorable temperature conditions semi-solid sewage probably will produce a maximum number of flies, provided it remains long enough in a relatively undisturbed condition. The more liquid the sewage the less likely is it to support the more dangerous house invading species, namely, flies which might contaminate food such as the housefly and blowfly. Fly larvae are subject to drowning in liquid. This does not apply so forcibly to the rat-tailed larvae referred to later.

No doubt the desire to control flies at sewage treatment plants is based on a two-fold menace: first, danger from contamination by pathogenic organisms of faecal origin; and second, that of wholesale fly production. The first menace would appear to be greatest where the green sewage is exposed directly to flies. This it would seem to me could be obviated largely by adequate screening. It would appear that most of this danger as well as fly breeding could be and ought to be obviated by the simple device of screening so far as smaller installations are concerned. The screened structure should be high enough over the sewage plant to admit the tenders. Why screens are not generally used, I do not know. Certainly the exposure of green sewage to flies ought not to be tolerated, particularly when treatment plants are not far removed from human habitations, dairies, slaughter houses, etc. The distance that flies travel, has been the object of experimentation by a number of investigators; for instance, Bishopp and Laake[1] have found that 'musca domestica' spread a maximum distance of 13.14 miles from the point of release and that marked specimens were found to have travelled a distance of over 6 miles in less than 24 hours. Flies have a tendency to spread with the wind, though they are known to travel against and at right angles with it. These two authors conclude that "the influence of moderate winds on dis-

*Professor of Parasitology, University of California.

[1] Bishopp, F. C., and Laake, E. W., 1921. Dispersion of flies by flight. Jour. Agric. Res., Vol. XXI., No. 10, pp. 729-766.

semination is not of great importance". They also conclude that the passing of vehicles along highways was not a dominating factor in dispersion.

Principal Species Concerned—Among the commoner species of flies breeding in sewage are the following: 'musca domestica', the common housefly; 'calliphora erythrocephala' and 'C. vomitoria', blue bottle flies; 'lucilia sericata' and L. caesar', green bottle flies; 'fannia scalaris' and 'F. canicularis', latrine flies; 'sarcophaga haemorrhoidalis' and other species of 'sarcophaga', commonly known as flesh flies or carrion flies; 'eristalis tenax' and other species of 'eristalis', drone flies, so-called because of their resemblance to drone bees; and 'muscina stabulans'.

Of the above named species, only two or three are really house-invading as already suggested. Of all flies taken in houses in various parts of the United States and reported by Howard[2] nearly 95% were 'musca domestica'; others, notably Kobayashi[3] for Japan and Korea, have reported about 90%. The remaining 5 to 10% consist particularly of 'calliphora spp'. (blue bottle flies) and a few others. The green bottle flies, 'lucilia spp.', are typically out-of-door species although they do find their way indoors now and then. The latrine fly and lesser housefly, 'fannia spp.', are commonly found indoors, but have the habit of circling and swinging back and forth almost ceaselessly toward the middle of the room and near the ceiling. They seldom if ever actually alight on the food on the table or in the kitchen. The drone flies (adults of the rat-tailed larvae), 'eristalis spp.', are flower flies, never occurring indoors except by accident. So far as health or even comfort is concerned, really no attention need be given them.

Trapping Flies—Fly traps are no doubt of some importance in mitigating the fly nuisance at sewage treatment plants. Traps should be as simple as possible and can be readily made or may be purchased. It must be borne in mind that a fly trap must be provided with bait. Files do not enter a trap just because it is a fly trap. The sense of smell plays a most important role in the life of the fly, hence suitable substances must be used as bait. As bait for houseflies

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[2] Howard, L. O. 1900. A contribution to the study of the insect fauna of human excrement. Proc. Wash. Acad. Sci., Vol. II, Dec. 28, pp. 541-604.

[3] Kobayashi, Harujiro, 1918. House frequenting flies and their seasonal prevalence in Japan and Korea. Mitteilungen der Medizinischen Fachschule zu Keijo. (Separatabdruck).

Bishopp[4] recommends the use of a mixture of cheap molasses (blackstrap) one part, and water three parts. For blow flies he recommends 'gut slime', which may be obtained from meat packing houses where sausage casings are prepared.

If repellents are desired, the use of creosote oil is suggested. Painting beams and other surfaces where flies are inclined to congregate has given good results.

Control of Fly Larvae—Much of the fly breeding in connection with sewage works occurs in the sludge beds at the end of the treatment process. In dealing with this problem the fact must not be overlooked that the full grown larvae have a strong tendency to migrate (Hutchison[5]) to drier situations which may take them outside of the sludge bed area. Even immature larvae will leave the pabulum when it becomes dry.

This migratory habit of immature larvae indicates a method of control which is probably impractical in the present connection, but it is well to bear in mind that when even the most favorable pabulum is spread out thin to permit of rapid desiccation, it is quite unfavorable for fly breeding.

Treating, perhaps sprinkling, the infested sludge with a liquid containing chemicals lethal to the larvae would appear to be a reasonable procedure. For the destruction of fly larvae in human excrement the use of sodium cyanide, one ounce to a gallon of water, has given good results in Nanking, China, as reported to me by my colleague, C. W. Woodworth. This solution was simply applied to the excreta by means of a hand-sprinkling can. Whether a similar method could be applied to maggot infested sludge remains to be seen.

A representative of one of the leading oil companies has informed me that an oil will soon be on the market for the purpose of controlling fly larvae in manure or other breeding materials. This should be tried out on sludge. In any case, cost of material, length of time it remains effective, and ease of application in addition to its larvicidal effect, must be taken into consideration.

[4] Bishopp, F. C. 1925. Flytraps and their operation. U. S. Dept. of Agr. Farmers' Bul. No. 734, 14 pp.

[5] Hutchison, R. H. 1914. The migratory habit of housefly larvae as indicating a favorable remedial measure. An account of progress. U. S. Dept. of Agr., Bureau of Entom. Bul. 14 (professional paper), 11 pp.

Except when maggots or pupae are present, the use of insecticidal chemicals is not recommended. Mechanical or natural means of control based on a knowledge of the habits of flies are preferable.

DISCUSSION.

R. F. Goudey, resident engineer, State Department of Public Health, Los Angeles Office, reported that during the spring and summer of 1925, there was a big epidemic of flies at the Pasadena sewage treatment plant. The breeding of flies was occurring in 101 separate sludge beds containing 2 to 4 ft. depth of excess activated sludge, covering about 10 acres. The second source of fly breeding was in a 40-acre orange grove where filtered sludge, about 85% moisture, was being disposed of on the surface of the ground, and partly plowed under for fertilizer. Subsequent applications brought old material to the surface and aggravated fly breeding.

The breeding of flies due to these two conditions caused extreme nuisance to people living 500 to 1000 feet from the plant. In the buildings around the plant, flies literally covered inside and outside walls. Never before or afterward have I seen such heavily infested areas of flies.

The steps taken to effectively remove the fly problem included: first, deep plowing of the orchard and discontinuing adding any more sludge to the orchard; second, sprinkling the sludge beds with 1 lb. of calcine colemanite (crude calcium borate) on every 10 cu. ft. of sludge, and then pouring 2 or 3 gal. of water over the surface. This method did not prove effective because the sludge continually cracked and exposed new surfaces. The borate cost $5.15 per 100 lb. It likewise was not practical to spray with oil because the crust which formed at the surface would not allow the oil to penetrate, and likewise new areas were being constantly exposed to the surface.

The practical solution which was worked out, was to dig trenches and move all of the lagooned sludge into pits. These pits were then given a top coating of asphalt and gravel, exactly as one would construct an asphalt road. This hard surface prevented flies gaining access to the sludge and likewise prevented maggots from crawling out. It cost $4500 to bury all of this sludge, and required about two months' time. Fly breeding was effectively stopped.

Gypsum was tried as a method of fly control, but was not effective. It facilitated in de-watering sludge to where the flies could not breed in it.

Professor Herms added that the modern sewage treatment plants do not have a big fly problem, and that at Santa Cruz plant, for example, he saw fewer flies than he has seen at some modern bakeries and other manufacturing concerns. R. F. Goudey agreed with Herms that chemicals should not be used, but the conditions that breed flies should be found and controlled.

A. M. Rawn reported a serious fly problem at the Los Angeles County Sanitation District plant, where raw sludge is run to beds. Last year a small brown fly and a very small black fly, bred, and this year the house fly is breeding. Between midnight and seven o'clock each morning countless millions were burned, but the house fly can not be reached by burning. Operation of three unused tanks as digestion tanks with discharge of digested sludge, which dries more quickly, has checked the trouble. His advice is not to expect raw sludge to dry on beds without a fly nuisance. A blow torch on top of the sludge raises the temperature only four degrees, for one inch below the surface, due to almost perfect insulation, so it is almost impossible to burn the larvae.

W. F. Rantsma said he thought Fresno had as bad a fly nuisance as any city. Their experience checks up on chemicals not being effective, and he considers their use a waste of time. Traps are now used, about 18 in. by 2 ft. high, with black strap molasses. Chemicals are used on the flies caught, and then they are burned, otherwise sometimes they come back to life. Flies breed on the surface of open tanks. Formerly when the tanks were covered, there were no flies even though the tanks were not screened; but they could not be cleaned, so the covers were removed and since then there has been fly trouble. Screening at a cost of $12,000 to $15,000 per year would control flies, but at present they do not have the money.

Merle S. Foreman told of an experience at Tulare where larvae grew very thickly; but only a few pupated, probably due to rapid drying of sludge.

F. A. Batty reported trouble with fly breeding in screenings at Hyperion regardless of the depth of cover. Spraying with 1½ lb. of pure carbolic acid and 40 lb. of caustic soda in 60 gal. of water has controlled them.

Harold F. Gray confirmed other speakers and said he felt the essential question was quick drying of sludge.

Professor Herms, replying to a question, said that

quick drying was more important than temperature in controlling flies. He said he had heard of instances when beams of light entered a septic tank through a knot hole in the roof which also allowed flies to enter, and as a result a vast number of eggs were deposited in the vicinity of the hole, indicating that tanks must be completely covered and completely darkened. He described the life cycle of 'musca domestica', as varying with the temperature. With increasing temperatures, the length of time of each stage is lessened. In summer, the egg stage requires about 24 hours, followed by the larval stage. If ample food is present, the larval period is usually four days, then the larva migrate, and in 24 to 36 hours pupates. The pupa stage is greatly affected by changes in temperature. In summer it usually lasts 4 to 6 days, when the fly emerges. Nine days is the very shortest for the life cycle, and this time is lengthened by decreasing temperature.

Sewer Grades

By A. M. Rawn*

From discussion of permissible sewer grades with engineers of California and elsewhere, I find a disparity of opinion as to just what may be the limit taken to define a flat grade for sanitary sewer design as compared to one not so designated.

The city and county of Los Angeles use for the design of their large systems a grade which will produce a minimum velocity of 2 ft. per sec. with the pipe flowing full or half full. Grades producing less than this velocity are termed by the engineers of this section, flat grades.

Some of the other cities, notably Fresno, Modesto, Tulare, Lodi, Clovis, and no doubt many others, commonly adopt grades producing a velocity of less than 2 ft. per sec., and accept them as standards in design and construction. To the engineers designing these systems 2 ft. per sec., designed velocity would be the unusual, and their definition of a flat grade might be taken to mean one producing a velocity of less than 1 ft. per sec.

For the purpose of this discussion two feet per second is assumed as the velocity dividing flat grade lines and what I shall term sharp grade lines.

The carrying ability of water is such that it moves solids along by dragging, by temporary or intermittent suspension, or by continuous suspension; and by one or all of these means the solids are transported in a sewer pipe. The transporting power of water may be increased by an increase in depth, the velocity remaining unchanged. These attributes of water have been coupled with sedimentation experiments from time to time, to produce the criterion of 2 ft. minimum designed velocity for sanitary sewers, to prevent sedimentation in the pipe.

No doubt the results are clouded somewhat by storm sewage and street drainage, and it can be said with certainty that 2 ft. per sec. designed flow is not a definitely proven figure. It can be stated with equal certainty that it affords a safe minimum velocity and one which will occur under practically all conditions

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of contribution to a large sewer system in a metropolitan district.

For sewage areas contributing to one outlet, such as that of the city of Los Angeles or of the Los Angeles County Sanitation Districts, and allowing for the removal of countless kinds of waste material that these systems attempt, a safe scouring under practically all conditions seems to be imperative. There are isolated sections of both systems in which sewers are of necessity laid on flat grades, but the systems in the main incorporate sharp grades and resort to pumping stations rather than flat grades, if and where there is any likelihood of the sewage changing its characteristics from purely domestic, to industrial waste suspending a reasonably heavy solid.

In a discussion presented at the spring conference of the Sewage Works Association, A. M. Jensen, commissioner of public works, Fresno, pointed out that most of the flat grades in the city of Fresno were at the extreme ends, the beginning of the 6-in. lateral lines about the exterior boundaries of the city, and stated that though it might appear strange, the city had almost no trouble with these lines. This feature does not seem strange to me but appears to be perfectly natural. If flat grades are to be used at all, it is much better that they be used in the upper ends of the system and on the outfall and not between these two extremities, because at the lower end of the main, should the sewer get blocked or clogged, there would probably be no connections which would flood before the sewer could be cleaned or clean itself. The same would be true at the extreme upper limits of the system with very few connections. This would not obtain, however, in the intermediate locations under like conditions, and it is probable that the intermittent self-cleansing of such sewer lines would cause an endless amount of trouble in adjacent basements and the like.

For those systems which require refined sewage treatment and are large in their tributary area, flat grades and slow velocities impose a burden on the sewage treatment process, that appears to me to be out of proportion to the amount of money saved in resorting to flat gravity lines rather than pumping stations. This is a hard question to settle except in the individual systems. I do, however, feel sure that low velocity sewers will settle out certain solids which tend to become septic along the line and materially influence the degree of treatment at the plant. It must be apparent that even in intermittent suspen-

sion of the solids, the time factor in moving from the upper reaches of a system twenty odd miles in length to a treatment plant will be materially influenced if the sewage does not flow freely with practically all of its solids in continuous suspension. No reasonable amount of flushing in the small tributary lines will overcome this feature with flat grades and low velocities.

In spite of the fact that sharp grades are considered advisable, conditions under which the system is built, that is, size, topography, the method of treatment, and the amount immediately available for expenditure, will influence the engineer, and no doubt have done so, to depart from prescribed practice and use flat grades. The fact that these flat grade lines are nearly all successful in operation is due, in my opinion, as much to the size of the system and the relative location of the sewers as to any other feature. I believe that endless trouble would result were systems the size of those in Los Angeles county, to be built using uniformly flat grades and no pumping stations. A great many reasons could be given for this, but it is almost sufficient to say that the magnitude of a project materially influences its maintenance, and while a small organization might keep its finger very closely on the pulse of a small system, a larger organization would have a great deal more difficulty keeping close contact with a much larger system. Trouble would undoubtedly be the result.

There can probably be no limit set on the permissible grade of a sewer or a system of sewers without close study of the design of the system and even then it is likely that no two engineers will agree conclusively. Opinions of the very best authorities in sewer construction are at conflict on this question, nevertheless, I have the feeling that sharp grades for large systems are very advisable, and that undue liberties should not be taken with sewage velocity unless the system is of such size that the material retardation of the flow in the pipe will have no pronounced effect upon the maintenance of the system or the method and degree of treatment contemplated. I feel that systems the size of those in Los Angeles county are well justified in expending a considerable amount of money to keep the flow of sewage in the lines up to the scouring velocity at all times.

Referring once more to the discussion delivered at the Spring Meeting in Fresno, I know of only one outstanding instance where a serious obstruction occurred

in a sewer pipe because of a pair of overalls. The stoppage occurred in an 18-in. pipe and the overalls were still on the owner.

DISCUSSION

Marion L. Crist drew attention to the fact that Rawn's paper referred to a large sewer system. There are certain standards of design that all designing engineers attempt to meet, but it is not quite as stereotyped as it sounds. Minimum velocities vary from 2 ft. per sec. to as low as 1 ft. per sec. In the east, 8 in. is generally considered the minimum size consistent with good design, but here and in the south many systems have 6-in. pipe and some even smaller. In the matter of minimum velocity each problem is an individual one. Ground water conditions which greatly affect the first cost of sewers, is one factor; with ground water within 8 to 10 ft. of the surface, the first cost of installing sharp grades with pumping plants is much more than when there is no ground water to contend with. By keeping grades flat, it is sometimes possible to keep entirely above ground water. The economy of each particular system is a separate problem. Ofttimes we can accept certain difficulties in operation in order to avoid capital investment.

W. F. Rantsma gave the experience of Fresno, population 100,000, with very flat grades, in general about 1¼ ft. per sec. That means a grade of 0.3 in. to 100 ft. for a 6-in. sewer. Two men and a truck keep the system in operation and also have spare time for other work. From the experience in Fresno it seems that steep grades are more theoretical than practical.

A. M. Rawn pointed out that in a large system such as the one he is connected with, sharp grades are necessary because it would take many men to operate them and they could not be as familiar with the system as in a smaller one such as at Fresno.

Batty favored 2 ft. per sec., but could not say that 1.5 ft. per sec. gave more trouble, in fact worse troubles are on steepest grades. He thinks sewage would become more septic but for maintenance; and that 1.5 ft. per sec., is probably not harder to maintain than 3 ft. per sec.

C. C. Kennedy recalled an experience he had in Berkeley, where the worst troubles were experienced on steep grades. In one case where heavy damages were involved, it was found that the State School for Deaf and Blind had discharged manure and bale wire into the sewer. He was called out of bed in the middle of the night and found horses knee deep in sewage.

Where the head is greater, as on sharp grades, the damage is also greater.

W. O. Castello said that although Sacramento is quite flat, sewers are not designed for less than 2.5 ft. per sec. A new concrete relief sewer from 6.5 to 9 ft. in diam. averages 3 ft. per sec.; it is a combined sewer. Some sewers in the business district are flat, as low as 0.2%, but there is very little trouble maintaining the system.

G. A. Parkes brought out that stoppages frequently occur from foreign matter, such as sticks thrown in at manholes and incrustations from laundries and restaurants.

F. A. Batty said that when he was at Santa Barbara they never had a stoppage. In Los Angeles two years ago they had 1200 stoppages a year. Now the average is 15 a month, caused mostly by rags, roots, etc., rarely by sand. Careful records are being kept. In the year that 1200 stoppages occurred, 75% of the sewers were old and of poor construction.

D. E. Perry gave his experiences at Martin Sanitary District No. 1, where many stoppages occur from tree roots in old sewers, sometimes as many as 20 a month. Formerly stiff rods were used, but now a special high tensile strength steel which will not kink is replacing them. Two or three men turn the cable like a cork screw, and stoppages 125 ft. away from the manhole and sometimes more, are reached in 25 minutes. With rods it would require a quarter of a day. Sometimes a 2 or 2½-in. pipe is used as a guide from the top of the manhole into the sewer. Roots are broken off by the cable as it turns. It is a ⅝-in. Roebling cable costing $6 or $7 per 100 ft. Root cutters are used, but the fire departments do not like to lend hose and use it after it has been in sewers.

E. L. Wright said his experience with 2½-in. hose was that it went in all right but required muscle to get it out. He plans trying out 1½-in. hose, but can find no one who has tried it. He has not had success with ⅝-in. cable.

Relative Costs of Sewerage

By D. E. Perry*

In the sequence of its importance, the disposal of sewage does not receive the rank it is entitled to by the public. Health should rank first in the mind of the citizen, for without good health the efficiency of the citizen is reduced and he may become a liability, instead of an asset, to his relatives or the community.

The tax for maintenance of the county hospital and poor farm in Marin county is 32c on each $100 of assessable property, as against 15c for the maintenance and operation of our sanitary district, including that of the treatment plant. Our high school tax last year absorbed 75c on each $100 of assessed value Our elementary schools received 45c for maintenance and 34c for redemptions. Our kindergarten school received as much as did our sanitary district, and our junior college received 44c and will get more this year.

It appears that the public is more apt to attach too much importance to the cost of adequate sewers and sewage disposal, and to overlook the cost of inadequate modern sanitary conveniences and such necessities as are appurtenant thereto, including treatment plants, although the latter, if eliminated or neglected, may become a heavy burden to the public through the outbreak of an epidemic or the creation of a gross nuisance. Treatment plants will not operate properly unless they receive adequate and intelligent supervision and constant attention. A neglected treatment plant will become a greater nuisance than if there was no plant at all.

Considering the small contributions made by the taxpayer toward the running expenses of our sanitary district, as aforementioned, as compared hereafter, and as indicated in our delinquent tax lists; it may safely be said, that no public or governmental activity ren-

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ders as useful and beneficial service to the citizen, or as economical a service, as does this sanitary district, and the same might properly be said of other districts operating under the 15c tax limitation, as specified in most of the sanitary district acts. Attention may now be drawn to the fact that this limitation, set by the legislature 30 years ago and long before treatment plants were in vogue, has never been raised, and we all know that 15 cents does not travel as far as it did 20 or 30 years ago, hence sewers can neither be built as cheaply, or maintained, or sewage treated in plants operated under present conditions, for as little as it cost 20 or 30 years ago.

It is up to such organizations as the California Sewage Works Association, to educate the public along such lines and to draw the attention of our legislators to the fact that we require more intelligent adjustments in our sanitary acts, so that they may be in keeping with the times. Our present fragmentary and confused sanitary legislation should be revised and consolidated. We should be given workable legal machinery. We should be able to get value received for the service we render. The public is getting more critical. The communities are building up more rapidly. Old sanitary sewer systems are being replaced with more modern and deeper sewers and consequently more money is needed. Modern apartment houses, costing frequently over a million dollars, cannot be built on a street where the main sewers are 3 or 4 ft. deep, for basement facilities must be provided for. They had this difficulty at Glendale several years ago and it cost over a million dollars to do properly what should have been done, and which could have been done, for a comparatively small sum 20 years earlier.

Healthy physical surroundings in keeping with the requirements of the times must be maintained, and the governing bodies must see to it that the elementary requisites for health are established and taken care of, irrespective of the wishes of the people locally concerned. The removal of nuisances, the prevention of contagion, the improvement of public health, the transportation, collection, disposal and the utilization and removal of sewage, are, in my opinion, much more important than the curing of diseases. The ounce of prevention still remains better than the pound of cure; and as sewage disposal is a case of 'out of sight, out of mind' with the average citizen, it is up to such bodies as this to advertise and

educate the public up to modern standards. Our officials are like:

The fish never cackles 'bout
Its million eggs or so;
The hen is quite a different bird,
One egg and hear her crow.
The fish we spurn, the hen we praise,
So folks, if you are wise,
Don't hide your light, but blow your horn,
It pays to advertise.

It has been said, with some truth, that, as a matter of fact we really earn our living by taking in each other's washing; and we, in the sanitary service, realizing that better health and comfort brighten the outlook on life, and create a civic pride that in itself far outweighs the expense involved, thus furnish sunny wash-days for this mythical public laundry.

Now back to the subject matter of this paper. The public is continually howling about rising taxation. Ours is, and has been, limited to this standard 15c for running expenses. When bonds are voted for construction, the citizen is solely responsible for interest and redemption disbursements; nevertheless he howls unintelligently, and to such an extent, that one wonders why the savages of Africa and elsewhere, where they pay no taxes, really become so savage. Citizens seldom talk intelligently when it comes down to taxation facts; and to combat loose and frequently wild talk, I inform them that they never spend a dollar on themselves as well as we, of the sanitary district, spend their money. I tell them, that on the average throughout our district—where we serve a population of 12,000 persons in four municipalities with 6500 pieces of assessed property and a revenue therefrom of $9500 per year, or a yearly contribution of less than $1.50, or 12½c per month, or less than ½c per day, which also means less than the price of a shoe-shine or a soft drink per month—that they have no 'kick coming' from the petty contributions toward our running expenses in this district.

I also ask them if they can think of any personal 12½ cents they spend, that does as much for them, as we do with our 12½-cent contributions; and never do I find anyone able to show that he spends his money as economically as we spend this $1.50 per year for him.

There are 365 days in the year and we get 150 cents, not per capita, but per assessed piece of property, per annum. Twelve thousand persons, paying

$9500 per annum, means a per capita contribution of about 70 cents for the year. The collected evidence shows that it costs about $1.00 per year per capita, to treat and handle sewage at treatment plants when such plants are properly operated, without reference to the many expenses incidental to many miles of main and lateral sewers to be repaired and otherwise maintained, as well as the cost of assessing, writing up the rolls, purchasing the same, printing, writing and mailing the tax bills, all of which, in our district, absorbs from $700 to $900 of our $9500. This equals nearly 10% of our revenue and as we still have to get our energy from the private utility, we pay them from $45 to $90 per month for electricity, which is sold under public ownership, at Tacoma, at Winnipeg, throughout Ontario and elsewhere, for about one-third of what we have to pay for it; these cities, at their low rates, paying for their systems, as well as getting good service. Authentic evidence is now before us, indicating that energy can be profitably generated, and is being generated at Hetch-Hetchy (San Francisco's water supply project) transmitted to Newark, and there sold to the P. G. & E. Co., for ½c per kw.hr., and that company shoots it across the bay and distributes it to the same people from whom it buys it, for 5c per kw.hr., for domestic lighting purposes. That is ten times what they pay for it. San Francisco made $2,000,000 profit, over operating expenses, bond interest, and redemptions while selling it last year to the P. G. & E. at this half-cent rate. We pay 3.6c per kw.hr. for the first 750 kw.hr. we use. That's that.

To some people I say, "How much does your 'phone cost you per year?" and they usually tell me "from $24 to $30". I then ask them, "If you had to dispense with either one, as between your sewer or your 'phone, which would you do without?" and they usually reply that they would abandon the 'phone, the sewer being more useful to the family. Then, when I draw attention to the fact that they do not pay the sewer utility a monthly rental in advance, as they do for the 'phone, but pay $1.50 on the average to the sewer utility, or twenty times less than the 'phone costs them, they then commence to ponder over the comparison.

Our health department informs us: That we can abolish typhoid, diphtheria, malaria, smallpox, scarlet fever, typhus, tuberculosis, dysentery, and possibly such diseases as infantile paralysis and the various

types of meningitis, and other communicable diseases, if we are willing to spend one-third of what we do spend for soft drinks, shoe shines, face powders, lip-sticks, or one-tenth of what we spend for moving pictures or gas for our pleasure cars. By bettering health conditions we are not alone adding a few years to helpless old age, but we are prolonging a healthy and happy usefulness.

State Supervision of Sewage Disposal

By C. G. Gillespie*

The foundation of this government is strong local self-government, based on the theory that many civic matters are of local concern, and that local authorities are conscientious, able, and mindful of the state and national governments of which they form a part.

The laws are full of the application of this principle to matters of sewerage and sanitation as a local privilege. Ways and means are freely opened to the political subdivisions of the state to acquire and promote the use of sewers. As an illustration, the assessment acts put sewer systems in a preferred class so far as overriding protests are concerned. Another act allows the governing board to force connections to sewers once the system is installed. This is a power not given to any other utility. But the legislature also recognizes the possible widespread damage sewage can do, and says "You must do a good job in getting rid of the sewage". Damage to public resources, like water supplies and fish life, and the accumulating knowledge regarding bacteria in spreading disease, have broken down the entity of local territorial boundaries as far as sewage is concerned. The state has had to prepare itself by laws and an enforcing bureau to check negligence in sewage disposal and, as a means to the end, to encourage the building and use of sewerage works.

In California the State Board of Health was created in the 70's, but it was not until 1907 that the legislature passed an act to regulate sewage disposal, and not until 1915 that there was a Bureau of Sanitary Engineering to administer it.

The legislation of California, placing sewage disposal under the State Board of Public Health, is contained within the Public Health Act, last amended in the statutes of 1917, as Chapter 600. In addition, there are general laws relating to nuisances, which empower the abatement of any health nuisance, and afford the only official means the board has to hasten installation of sewers. Contrary to popular belief, the state has no authority to order building of sewers. But sewers may follow upon a drive to abate wide-

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spread privy and cesspool nuisance in a town, as the logical remedy to avoid abatement.

The sections applying to sewage disposal bring within its perview any substance which is, or may become, offensive or injurious to the health of human beings or animals. The act applies to sewage disposal in any of the fresh or salt waters of the state, or on the surface of the ground within the state; but cesspools or underground disposal are omitted as long as water supplies cannot be menaced.

The act requires the holding of permit for construction, extensions and use of sewage disposal works. The courts have held that the act applies to the use of sewers but not to their construction. No similar opinion has as yet been rendered against the need of permit in the case of construction of disposal works. In view of the importance of 'prevention' as contrasted with 'cure', and the obvious need of avoiding investments in sewage works whose use is abatable, it would be a serious public matter if a similar opinion were rendered against state contact with the disposal end of sewer systems until after they are built. We have found that our contacts need to be made early in the project to get best results for the money to be expended.

The act prescribes a permit mode of control and makes the owner of the sewage, whether it be a city, town, county, district, or private party, responsible for obtaining a permit and for the subsequent results. The impression is that a permit represents a really worthy sewage disposal. As a matter of fact, permits must hinge on minimum standards. Otherwise the act becomes confiscatory and burdensome.

Application for permit is made by the governing board and is accompanied by a description of a more or less technical nature, usually with plans, adequate to enable an understanding by the board of what is proposed, the conditions to be met, and the reliability of results to be expected. As time has gone on, these reports are more and more fully furnished by the engineers. We once had a report form, but as no two problems are alike the reports proved quite useless. The reports are then reviewed and transmitted by the Bureau of Sanitary Engineering of the State Department of Public Health to the Board of Public Health. Permits are not issued by the bureau. The board may hold hearings, but this is not obligatory.

The act prescribes that if the final findings are

such that under the circumstances it is necessary to dispose of the sewage in the way proposed, and that there is no reasonably prospective nuisance or menace to health, permit is issuable. Under contrary findings, permit is to be denied. When permit is denied, the board is empowered to grant temporary permit and to issue orders of rather sweeping consequence for betterments to the disposal, extending even to the employment of an operator at the expense of the city. This latter prerogative and dictation to the cities as to what they shall do, have never been resorted to by the board. Instead, the board prefers to analyze the results to be met, the problems in its solution, and leave the choice of project to the local community.

In sewage disposal, which is a new and developing art, it seems especially important to try new things. For that reason the bureau and the board have been most lenient in allowing leeway and opportunity for trial of any new ideas, asking only that the public which pays the bill understand the degree of experimentation. Not all that has been tried has proved successful, but on the whole California has made remarkable advances in better sewage disposal in the past fifteen years. Permits as issued may be revoked or suspended for cause.

Finally, the act specifies penalties which are no less sweeping; embracing injunction, fines, and imprisonment of the responsible officials for failure to hold permit or comply with board requirements. This portion of the act likewise has never been used.

The only rules adopted by the board, regulate use of sewage on vegetables, fruits, and berries.

The courts have held that a mere holding of a permit is no defense to the perpetuation of a nuisance; but in the eyes of the court, failure to hold a permit required by the law contributes to the evidence of negligence on the part of the city.

It must be apparent that the intention of the legislature in the Public Health Act was merely to safeguard those whose health might be damaged by careless sewage disposal; and for this reason, in a showdown, the state requirements are in truth 'minimum requirements', and generally far less than the purely local requirements. Nevertheless, permits as granted stand for projects which are in many cases highly creditable and a pleasure to operate. Or, if this is not the case, the plan at least is good, and when it is fulfilled the project will be a good one.

In many cases, communities having a problem hesitate to undertake its solution or even to employ an engineer, not knowing to what expense the venture may lead. It frequently happens that the bureau is consulted in such cases to outline the possible projects and obstacles in the way, and to give the communities some assurance that a project is within reach. In earlier years this mode of operation was carried rather extensively into sanitary surveys of unsewered territory, and many sewer systems resulted from them.

In a more purely educational way, articles and publications on various sewage subjects have been put out by the bureau. These have done much to crystallize thought and steady the practice around the state.

With a few interruptions, the bureau has always had some sanitary engineering laboratory facilities with which to study problems of particular wastes and operating performance of plants. We need more laboratory facilities very badly.

I would say, taking the country over, the states have satisfied the public needs in the general supervision of sewage disposal in a manner that has been quite satisfactory to all concerned, and California will stand comparison with any state. The motives of the states have not been punitive but have been educational and cooperative with the communities. How much the courts have been spared and how much the state and its political subdivisions have advanced toward a more wholesome existence through this friendly relationship, no one can truly estimate.

One grand result has been the development of a local and neighborly conscience in sewerage matters, which no amount of policing could ever have attained. I feel that the willingness to do the right thing is so universal that our resources will not be seriously wasted through future insanitation. Even in our harbor pollution and Mother Lode stream pollution, which are the most perennial of California's sewage problems, there are hopeful signs of local unrest.

Like other states, we have aimed to take a friendly, patient stand with cities and operators. It makes our work easy and pleasant, but what is more it develops local reliance and initiative. The fact is, our communities are moving ahead fast in better sewage disposal.

With the great multiplication of sewerage and complex treatment works, and yet no increase in staff, the problem before the bureau is plainly to withdraw from various modes of pioneering procedure it once

could pursue. So far the results to the state are not as bad as one might think, because others, like the consulting engineers, the manufacturers of sanitary equipment and supplies, and local health departments, have grown to be a broadcasting medium for sewage disposal intelligence around the state, far more extensive than our small means ever allowed. In fact, looking ahead and mindful of the ceaseless cry for lower taxes, the position the bureau is coming to, is obviously that of passing on permits and thereafter keeping such superficial tab on the general situation around the state as it can.

Already we feel our contacts with operators becoming less. On an average we only see them once in a couple of years. The conventions of the California Sewage Works Association will go a long way to offset this. How long, however, the loss of field contact can go on with safety is a question. So far we have kept a good understanding on what is going on around the state and know pretty well when and where conditions call for attention. Thus it may still be said, that the interests of the state in what the various communities are doing or are not doing, is adequately served. That the system is reasonably effective, and certainly economical to the state, is attested by the high position California occupies in sewage disposal matters in the Union and the good typhoid record it has exhibited for a decade or more, in spite of its tail-end rank among the states in the support given to the Bureau of Sanitary Engineering.

Municipal Responsibilities

By B. J. Pardee*

A municipality has many powers, duties, and responsibilities, and among the most important of these is the police power or the particular power that has been invested in the city giving it the authority to protect the lives, morals, health, and property of its citizens, and as such, has to do with the drainage, sewerage system, and sewage treatment and disposal plants.

The courts have long recognized this power and duty as being a proper function of a governing body, the first recorded regulation being in the old mosaic law where proper edicts were issued to control the disposal of excrement from the human body.

The English common law (the basis of our California law) recognizes this power as vested in a municipal corporation.

Our own codes, statutes, and court decisions have also fixed the power to control sewers and sewage works as a proper police power of a city, and from the trend of court decisions I am of the opinion that they will further hold that cities have the very broad power not alone to regulate the conditions of the present, but also to take care of those conditions that may arise in the future development of our civilization, together with its attendant industries and occupations; and will no doubt take into consideration our ever changing mode of living, together with the fact that if the esthetic side of life, if not quite as important as the strictly sanitary requirements, is quite as desirable.

Regulations of the future will not alone require that sewage be cared for in a sanitary manner, but also in a manner in harmony with the five senses of man.

The courts hold further that the city council, under its administrative power, can design and construct sewers and disposal plants, and that their acts in so doing cannot be reviewed. Further, that the city cannot be held responsible for its failure to construct or for the inadequacy of either system or design; but for a failure either in design or operation that injures either persons or private property, the city is liable for damage.

*City Manager, Visalia.

The city under proper eminent domain proceeding, can acquire private property on which to construct sewers or disposal plants; but if adjoining property is damaged in the operation of such a plant, the city is liable. Eminent domain proceedings are entirely separate from the police power, the one having to do with the acquirement of private property for the common or public use by the payment for such property; the other having only to do with the proper protection of persons and property, even though it may regulate and restrict the occupancy of any private property.

A city is within its rights to compel a connection of a property to a public sewer, and may make a charge for the same, but such charge must be uniform and not unreasonable.

Again, a city is held responsible for the proper operation of a sewer and also for a sewage disposal plant, and while I do not think that a charge to a special plant on account of any peculiar condition of its sewage can be collected, the city can, of course, under its police power, compel any objectionable content of a given sewage to be removed, or harmonized, before it may be emptied into the public sewer.

It is quite apparent, that further than this police power that may compel certain things to be done, there is a moral obligation that a municipal corporation owes to its citizens, which has considerable bearing on the matter of policy as between a city and its industries.

A city is a vortex that brings to a common center all manner of men and things. This thing we know as a municipal corporation must serve them all, and if it is good for man and his property that wastes of a personal nature be collected and disposed of by the city, I can see no logical reason why the waste from industry should not be collected and disposed of at a cost to the common purse.

It is quite difficult to tell just what benefit any particular industry is to the community as a whole, but suffice it to say that whatever it is, and however difficult its trade wastes may be to dispose of, there is some benefit derived from its presence and operation, and the community as a whole, as a matter of policy at least, should pay for the proper disposal of its wastes.

Summing up the whole situation, it seems to me that the duty and responsibility of a city is:

First: That trade or other waste of an unusual or

difficult type be harmonized at the place of origin. Second: That in the assembling of all wastes, trade or household, through private municipally regulated sewers to the public sewers and thence to the disposal plant, the responsibility of operating the system and plant be entirely that of the city.

DISCUSSION

C. H. Lee inquired if there were any instances where trade wastes had been harmonized with the general sewage of the city. Pardee replied that in several eastern cities unreasonable charges could not stand. M. L. Crist reported that the city of Salinas is building a small treatment plant at the cannery at city expense, and the operation cost, estimated at $1000 to $1500 per year, will be paid by the cannery. Chas. H. Lee brought out the fact that in some instances treatment works had been doubled to provide for industries. G. A. Parkes remarked that there were two sides to the question; while the industry is a benefit to the community it operates for a profit and is not a charitable institution. An additional cost for sewerage would simply increase their costs and the consumer would pay for it in the end. Alva J. Smith said he knew of a city of 25,000 where the capacity would have to be increased three times to care for trade wastes from a business operated for profit, and he could not see the justice of putting the burden on the taxpayer.

Forsythe said if we pay the expenses of any industry we give that industry a favor over those in other communities. It is like the former plan of telling industries, "We will give you a plant site—we will build your plant"; we no longer do that because we realize that the industry must stand on its own responsibility.

W. F. Rantsma referred to the cheapness of sewers, the cost being 12½c per month, but said he believed that if a special sewer-service charge were made, it would cost about 12½ cents to collect the charge. He thinks a few thigs in the world must be free and sewer service is one of them.

O. E. Steward reported that the Orange County outfall sewer has 25 contributors paying monthly rental; $700 per month for a flow of 40 c.f.s.

D. E. Perry presented the idea that free sewer service might be all right for cities having funds, but where the revenue is fixed at 15 cents, as in sanitary districts, and men will not work for nothing, an industry charge is equitable and should be paid.

Float Surveys and Ocean Outfalls, Santa Cruz

By CHARLES GILMAN HYDE*

Float Surveys—San Lorenzo river flows in a southerly direction to Santa Cruz harbor, and equally divides the incorporated area of the city of Santa Cruz. The natural drainage of the major portion of this area is toward the river and harbor and the natural point of concentration of sewage is at or near the mouth of the stream. To such point most of the sewage could be conducted under a head sufficient to permit fine screening and discharge into the harbor by gravity. The sewage from the lower areas would require to be pumped. The city's sewers have nominally been built on the separate plan. However, the wet weather flow is greatly increased, either through direct discharge of roof waters, or because of poor construction of certain of the older sewers.

In the belief that the logical point of outfall of the fine-screened sewage was in Santa Cruz harbor, offshore from the mouth of San Lorenzo river, steps were taken to obtain the necessary fundamental information. Hydrographic data were obtained by actual soundings and by reference to the U. S. Coast Geodetic Survey maps of Santa Cruz harbor and Monterey bay. Tidal statistics were obtained from the comprehensive tide tables annually published by the Survey. Current directions and velocities were determined by float surveys. These were conducted during April and May, 1925. The floats were released from selected stations under all usual conditions of wind and tide.

Float Types and Use—Three principal types of floats were employed in the work. These were:

(1) Shallow surface floats: bottle (submerged depth 9 in.), and vane (submerged depth 12 in.)

(2) Deep surface floats: light vane (submerged depth 9 ft.), and heavy vane (submerged depth 5½ ft.)

(3) Sub-surface floats indicating the direction of the deeper currents, irrespective of surface conditions (submerged depth 20 ft.)

The deep vane and subsurface can floats whenever possible were picked up and re-used. The bottle floats were never recovered and were allowed to go until

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lost at sea or stranded on shore. Similarly, for the most part, the small vane floats were not picked up.

In all, there were 178 float releases, the deep surface or large vane floats and the sub-surface can floats being repeatedly used. The distribution of observations among the several types of floats was as follows:

Shallow surface: bottles—99; vane—23; Total	122
Deep surface; light and heavy vane,	34
Sub-surface or deep can,	22
Total	178

Floats were released from four different locations. Three types of floats were employed and the courses traversed representing all typical conditions were platted and studied. Two stations gave excellent results. That recommended for use was 4800 ft. from high tide line off-shore from the mouth of San Lorenzo river, where the depth at mean lower low water was 40 ft. Almost equally favorable results were obtained 700 ft. nearer shore, where the mean lower low water depth was 35 ft.

Every station was occupied throughout a considerable portion of the period covered by each day's observations. During such intervals floats of various types were released in accordance with a pre-arranged schedule. From time to time during the day, the motorboat, which was consistently employed for this work, would leave the station (designated by a proper marker so that return could be made definitely to the same position) and would find or attempt to find the floats which had already been released. The number of each float found, the time of day, and its position, as determined by a sextant, were recorded. When the deep vane and sub-surface can floats traveled a sufficient distance they were picked up, the time and location being noted, and later released from the same station if opportunity offered. In any event, all such floats were picked up at the end of the day if they could be found. In numerous instances they traveled so far that it was not possible to find them within the time available. As a rule, the maximum distance from any station through which the courses of the floats were followed and determined was two miles.

An attempt was made to trace the ultimate travel of all bottle and small vane floats through the use of self-addressed return post cards. One of these was inserted in each bottle and in the corked test-tube at-

tached to each of the small vane floats. Finders of these floats were requested to return information concerning the location at which they were found, together with their own names and addresses. Altogether, 42 cards were returned, of which number I found 6 and the remainder were recovered by other persons. Of the 80 unrecovered floats, it is probable that a considerable number drifted to distant points. Some were doubtless broken against rocky headlands, such as Black and Soquel points.

Results From Floats—The average rate of effective travel in a definite direction, of 37 bottle floats released from the recommended point of discharge of sewage, was 2300 ft. per hour, with a maximum observed rate of 4000 and a minimum of 440 ft., all based on one or more hours of observation. Six small vane floats traveled an effective distance of 2750 ft. per hour as compared with 2970 ft. for six bottle floats released at the same times. It would appear that the bottle floats were affected by the wind to a greater extent than were the small vane floats. Seventeen large vane floats, observed for six or less hours, traveled an average distance of 1750 ft. per hour, with a maximum observed rate of 3500 and a minimum of 340 ft. Seven heavy, deep-vane floats traveled at an effective rate of 1400 ft. per hour as compared with 2200 ft. for an equal number of bottle floats released at the same times. In all cases, the light deep-vane floats moved at a higher rate of speed than the heavier and deeper vane floats. The sub-surface floats moved at a much lower rate than the surface floats. Eleven such floats, released from a station, traveled at an average rate of only 220 ft. per hour, with a maximum observed rate of 600 and a minimum of 75 ft. It was apparent that the currents at 20 ft. depth were much more sluggish than were those in the upper 6 ft. The result suggests that sewage dispersion in this location would be more rapid near the surface and, provided that the current moved in a satisfactory direction, that the removal and dilution of sewage, together with its effective oxidation, could here be best accomplished by causing it to rise as completely as possible toward the surface.

A single series of float studies was made at the point where the present outfalls are located. These showed that the sewage would, at times, move rapidly shoreward and would tend to pollute the small beaches in this vicinity unless the diffusion and dilution were satisfactory. No bacteriological studies have

been conducted to determine the degree of pollution caused, if any. The beaches in question are not used for bathing purposes but they are frequented by picnickers and pleasure-seekers to a certain extent at low tide.

Plan Projected—The recommendation that the fine-screened sewage be discharged into Santa Cruz harbor at the point described was not concurred in by the city council for the following reasons:

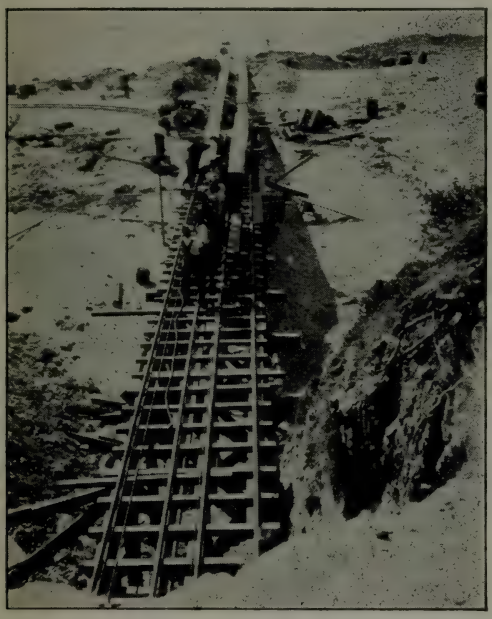
(1) That the controlling public opinion would not tolerate the discharge of screened sewage at any point in Santa Cruz harbor no matter how far distant from shore, or how convincing the testimony that such procedure would fulfill the most rigorous hygienic and esthetic requirements. (2) That the controlling public opinion and private interests involved could not consent to the erection of a sewage screening and pumping plant at or near the mouth of San Lorenzo river, no matter how logical that location might be, or how attractive such a plant might be made both as to structure and surroundings, and irrespective of testimony to the effect that suitable isolation would be a posiitve guarantee against odor nuisance. (3) That the popular opinion was that sewage should be disposed of by dilution, but that such disposal must be in the Pacific ocean and not in Santa Cruz harbor.

Wrought-Iron Pipe Outfalls—As harbor disposal was unacceptable I recommended that divers be employed to examine the ocean floor west of the lighthouse to determine whether or not a smooth lane of rock could be found, upon the surface of which outfall pipes might be successfully laid. The recommendation was accepted and the Merritt-Chapman & Scott Corp., of New York, and Wilmington, Califorina, was engaged to make the submarine survey.

A solitary lane of smooth rock surface, with some temporary migratory sand-covering near the shore, was found to extend due south from the intersection of the Cliff drive and Sunset ave. To reach this lane, a force-main in tunnel beneath the plateau extending from Neary's lagoon to the ocean shore, a distance of 4400 ft., was necesasry.

Description of Outfall—From a surge chamber near the edge of the cliffs at the intersection of Cliff Drive and Sunset ave., two outfall pipe lines, each 2000 ft. long, follow a southerly course to points of discharge in the Pacific ocean. The pipe lines are close together at the shore end and about 200 feet

apart at their discharge ends. At the surge chamber, provision is made for two additional pipe lines of the same size. From various preliminary studies it was determined that the pipes would be especially subject to sand erosion and to corrosion in a section 400 ft. long, beginning 100 ft. seaward from the surge chamber. The pipe is genuine hand-puddled wrought iron, 16 inches o.d., manufactured by the Reading Iron Works, Reading, Pennsylvania. It is ½-in. thick for



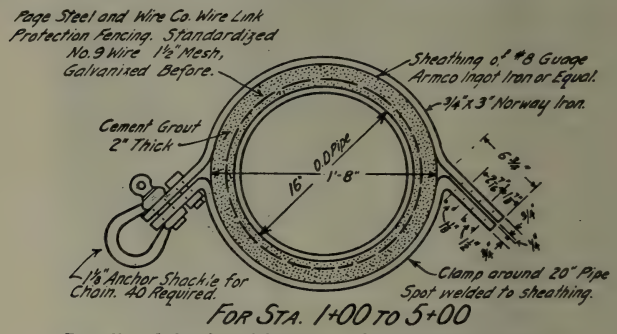
Two 16-in. Wrought Iron Ocean-Outfall Pipe-Lines, Each 1900 ft. Long, on Trestle During Launching. Trestle Afterward Removed and Pipe Across Beach Laid in Trench

the first 500 ft., and ⅜-in. thick in the outer 1500 ft., of each line. From 100 to 500 ft. from shore the pipe is protected by a 20-in. o.d. galvanized wrought ingot iron sheathing, 3/16 in. thick, fabricated by the Steel Tank & Pipe Co., of Berkeley. The annular space between the sheathing and pipe was filled with cement-grout, in which was embedded a continuous band of No. 9 gauge, 1½-in. mesh, galvanized wire link protection fencing, as made by the Wickwire Corp., of New York. The grout was 1 part of Portland cement to 1½ parts selected sand to which was added 2% Celite to improve its flowing quality. The grout was placed partly by a cement gun and partly by a special grouting machine devised by C. F. Butte of San Fran-

cisco, and used with success on the Watsonville outfall.

The remainder of each outfall pipe line was protected by a coating of gunite, 1 in. thick, in which was embedded a continuous band of wire link protection fencing. When thoroughly set, the gunite was coated with two coats of Biturine solution and two coats of Biturine enamel, furnished by Hill, Hubbell and Co., of San Francisco, and applied in accordance with the company's specifications. The work of guniting and grouting was performed by The Pneucrete Co., of Santa Barbara, California.

Constructing Outfall—The cliffs at the site of the surge chamber are 36 ft. higher than the beach across which the pipes are laid. From this point, the ground slopes gently toward the north. Each of the two shore

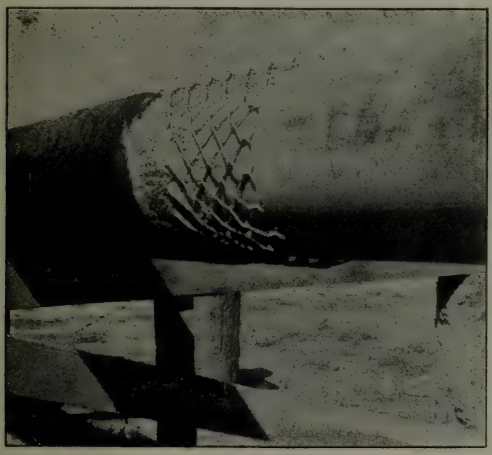

Page Steel and Wire Co. Wire Link Protection Fencing. Standardized No. 9 Wire 1½" Mesh, Galvanized Before.
Sheathing 0.1" #8 Guage Armco Ingot Iron or Equal.
¾"x 3" Norway Iron.
Cement Grout 2" Thick
O.D. Pipe
16'
1'-8"
1½" Anchor Shackle for Chain. 40 Required.
Clamp around 20" Pipe Spot welded to sheathing.
FOR STA. 1+00 TO 5+00

Details of Anchor-Flange on Ocean Outfall Pipes

sections, 100 ft. long, was assembled independently, and the remaining length of each pipe-line, 1900 ft., was fabricated on a special temporary right-of-way, 20 ft. wide, whose axis was substantially a continuation of the median line on which the pipe-lines were laid in the ocean. It was calculated that the pipes would not suffer damage if at no point they were allowed to take a bend having a minimum radius of 5000 ft. By constructing a heavy timber trestle on the beach; a tunnel 200 ft. long through the cliff and 20 ft. below the ground surface, sloping upward away from the shore; an open cut 150 ft. long and varying from 12 to zero ft. in depth; and finally a graded way to the further limit of the right-of-way, it was possible to lay steel rails on suitable ties on a profile with reverse grade, thus the pipe could be slid into the ocean without causing it to bend at any point such that the pipe or its protective sheathing or coating would be injured.

The wrought-iron pipe was delivered in 20-22 ft.

lengths, with chamfered ends. All joints were carefully welded, using refined Norway iron welding rods. The pipe was mounted upon wood trestles of proper height. When ready for launching, each outfall line was in turn placed by the contractor on car trucks especially arranged with suitable wooden saddles. Calculations indicated that the united portions of the empty pipe would have a negative buoyancy of 10 lb. per lin. ft., and the sheathed portions a negative buoyancy of 100 lb. To keep the pipe from bearing too heavily upon the bottom, wooden oil-barrels were fastened to it at 30-ft. intervals throughout the 1500-lb.



Wrought-Iron Ocean Outfall, 16-In. Diam., In Process of Being Covered with Reinforced Gunite Coating 1 In. Thick.

gunited portions, and at 7 ft. intervals throughout the heavier sheathed portions. The pipe was hauled into place from a barge anchored in line beyond the outfall end. On October 7, 1927, the westerly of the two outfalls was launched and the second line was launched on October 9. Instead of sinking to the bottom, the gunited portions of the pipe-lines insisted on floating, even after all barrels were removed. The heavier sheathed portions would have sunk except for the buoyancy of the outboard portions. The circumstance of floating proved to be fortunate, because the rock bottom was everywhere so smooth that anchors would not hold, and but little pull could be exerted by the winch on the barge. The pipe-lines were finally launched by such pull as could be obtained from the barge, plus a more effective pull by a winch about mid-position of their length, before launching was be-

gun. The outboard ends of the pipe-lines were provided with temporary welded funnels to prevent catching upon the rock bottom, and with permanent cast-iron flanges to which were attached temporary blank flanges and sea cocks operated by wires drawn through the entire length, 1900 ft. When these cocks were opened, the pipes filled gradually and sank slowly to their required position on the ocean floor. Barring slight temporary mishaps the pipe-lines were successfully launched. The first line was launched in 8 hours and the second line in less than 3 hours. Shortly after the pipes were laid, the blank flanges were removed by a diver and the terminal castings installed. These consisted for each line of a 16-in. long-radius, cast-iron flanged 90 deg., bend, looking upward, and a 12 by 12 by 16-in. reducing flange. This flange was a

One of Three Wood Rollers Releasing Pipe-Load from Trucks on Trestle

cast-iron tee, placed with its 12-in. outlets to discharge horizontally at right angles to the axis of the outfall pipe. The horizontal axes of the tees are 4½ ft. above the ocean floor, and at the same elevation. They are hydraulically equivalent and discharge equal quantities of sewage. At their locations, the depth at mean lower low tide is 37.2 ft., and at mean tide (mean sea level) 40.4 ft. A terminal concrete anchorage was constructed on each line with specified base dimensions of 13 by 15 ft., top dimensions of 4 by 5 ft., and a height of 3 ft. Four other similar anchorages, of different dimensions, were constructed shoreward on each line at intervals of 300 ft. These anchorages were made by diver. The concrete mixed fairly dry, was placed in sacks containing about 2/3 cu. ft. each. The sacks were gashed as laid, to insure proper bonding. Through a distance of 450 ft., beginning 100 ft. from

their shore ends, the pipe-lines were fastened together at 50-ft. intervals by 1-in. steel chains. Opposite each of these points, 25-ft. chains were laid normally outward from each line of pipe. These portions of the pipe-lines were laid on sand, in which chains are believed to be an effective lateral anchorage.

Inspections—After an interval of several months, the lines were thoroughly inspected by W. H. Huntley, diver, of Alameda, California, who found the entire installation to be in a satisfactory condition. One concrete anchorage, that on the westerly line nearest the shore, had been disturbed and partly destroyed by a storm which occurred within a few hours after it was laid. Certain of the other anchorages had apparently not been constructed to the dimensions called for, but they were found to be in good condition. It is possible that these so-called anchorages may increase the wave effects upon the pipe and thereby prove to be a detriment rather than an advantage.

Pipe Prices—Bids were asked on three types of pipe protection as follows:

(a) A biturine and canvas covering throughout; (b) a Biturine and canvas covering on the shore end from station 0+00 to 1+00, and on the outboard portion from station 5+00 to 20+00, with a sheathed section 400 ft. long from station 1+00 to 5+00; (c) a gunited and sheathed pipe as constructed.

Bids were also asked on three kinds of pipe, standard steel pipe, copper-bearing steel, and genuine wrought-iron. The bids of the successful contractor, J. H. Tillman Co., on these types of outfall were as follows:

Ordinary steel pipe, protection system A, $75,140.

Ordinary steel pipe, protection system B, $77,640.

Ordinary steel pipe, protection system C, $81,640.

Welded copper-bearing steel pipe, protection system A, $75,700.

Welded copper-bearing steel pipe, protection system B, $78,200.

Welded copper-bearing steel pipe, protection system C, $82,200.

Genuine wrought-iron pipe, protection system B, $88,500.

Genuine wrought-iron pipe, protection system C, $92,500.

The last-named figure was accepted and was the contract price for this item.

B.Coli Surveys, Los Angeles Ocean Outfall

By W. T. KNOWLTON*

Shortly after the city of Los Angeles completed the construction of its north outfall sewer and sewage screening plant at Hyperion, arrangements were made for records to be obtained along the Hyperion beach and vicinity, which would show the effect of the disposal of its sewage on ocean bathing.

Beginning in February, 1925, the beach waters in front of and adjacent to the Hyperion sewage treatment plant were tested for B. coli bacteria. These tests were made during 1925 at semi-monthly intervals along the Hyperion beach, at points less than one-half mile apart and for a distance of about two miles on each side of the outfall, which discharges 5100 ft. out into the ocean. These records were continued in 1926 and again in 1927. Beginning in November, 1927, the collections at each of the different sampling stations were made more frequently, and averaged ten times monthly during 1928. Since January, 1929, the collections have averaged fourteen times each month at each station.

In addition to the collection and tests which have been made of the beach waters in front of the Hyperion plant, B coli surveys have been made in the ocean sewage field, which has resulted from the discharge of the city sewage in this vicinity. These ocean surveys have been made twice yearly, beginning in 1925, and indicated the area of pollution which was in evidence on those days at the time of maximum flow from the plant.

In the annual report of the board of public works of the city of Los Angeles for the fiscal year ending June 30, 1928, the city engineer has included a map showing the location of the various sewage fields thus surveyed. An examination of the records obtained from these ocean surveys shows a gradual increase in the area of pollution, although the area per unit of flow is fairly constant. An average of nine ocean surveys indicates the area to be about four acres per second foot of sewage flow.

Recent surveys have been made of the hydrogen sulphide content in the flow in the north outfall sewer

*Sanitary Engineer, City of Los Angeles.

of this city. As a result of these sulphide surveys, it is possible that chlorine may be added to the sewage flow at various points along the outfall which will reduce the odor and deterioration in the conduit and at the Hyperion plant, and also decrease the field of pollution in the ocean. The ocean condition will be further improved by the installation of skimming tanks for grease removal at the plant. At the present time the city has in progress experimental studies and has installed demonstration tanks for this removal.

In order that the public health along the beaches may be protected, the California State Department of Health has for some time used a count of 10 B. coli bacteria per cubic centimeter as the limit of permissible bacteria contamination. Accordingly, this limit has been used in determining not only the area of the field of pollution in the ocean, but also as a limit along the beaches where they have been used for recreational purposes, such as swimming, fishing, boating, camping, or for picnics.

During the years 1927 and 1928, the B. coli records adjacent to Hyperion have shown at times some counts exceeding the limit above mentioned. These records, however, were not frequent. With the stopping of leaks which were found at the shore end of the outfall, the condition along the beach at Hyperion in 1929 has been very satisfactory from a B. coli standpoint. With an average of four collections per week at each of the various stations along the beach, the results of the surveys at the stations this year have shown a record of scarcely over one sample per month per station that has exceeded the limit of 10 B. coli per c.c. In these exceptional cases, the locations of the sampling stations have been adjacent to the outfall.

In addition to the ocean surveys at Hyperion and beach surveys adjacent thereto, samples of the beach waters have been collected at less frequent intervals along the entire coast of Santa Monica bay from Topango canyon to Redondo beach. As a result of tests at these locations, which are in many cases several miles distant from Hyperion, it has been noted that there is a count of more than 10 B. coli per c.c. which may be due to the use of the beaches for bathing.

On holidays and Sundays during the summer season, it has been found that a count of 50 to 100 or more B. coli per c.c. has occurred at points along

Santa Monica bay, over ten miles from Hyperion, whereas at other times the record is less than the permissible limit. These conditions lead me to believe that B. coli contamination may be caused by bathing only. In this connection it may be noted that the removal of sewage, which now reaches the beaches of Santa Monica and Venice by the discharge from their outfall sewers, should improve the bacterial conditions of those beaches. This removal will probably be in effect within a short time. Future B. coli surveys of these beaches will then determine whether the count is above the specified limit after the discharge of sewage has been eliminated therefrom.

It is believed that the records which have been kept of the bacteriological conditions along the beaches of Santa Monica bay during the past five years will prove of much value in the future, and especially in the vicinity of the Hyperion outlet. As far as possible, these tests should be taken almost daily in order that a complete record may be available for the protection of the public from any possible pollution. It is suggested that other cities along the coast of this state could, to advantage, obtain similar records at their beach resorts, even if the discharge of sewage may be at some distance therefrom.

Settling Tanks for Bay Outlets

By F. M. Lockwood*

The proper treatment and disposal of sewage is costly, and is a problem which calls for intensive study of all conditions which may be encountered before the plant is designed. In cases where no definite rule for the disposal of sewage was established the generally accepted plan has been that which gives reasonably good results with the least expenditure of money. It is only of recent years that the health officers of the state have realized that the proper treatment and disposal of sewage is one of the greatest and most important problems confronting them, and have petitioned the state to set aside a fund for scientific research.

Time was when dilution was considered the last and most efficient thing in the disposal of sewage waste. This method is still suitable when, by dispersing in water, the impurities are disposed of without nuisance or menace to health.

The first sewer system in San Diego was installed in 1887 by Waring, and discharged the raw sewage into the bay of San Diego. This system was followed by later installations, and at the present time there are some eight outfalls discharging raw sewage into the bay, the majority of them but a short distance from shore, and in no case extending as far as the channel. Fortunately this sewage is discharged in widely separated outlets; and consequently, the formation of sludge banks, and their attendant odors, has caused but little complaint. Such substances as float upon the surface are usually the cause of the complaints, but the bacteria, which are unseen, are far more dangerous. However, the floating substances have done much more toward stimulating the movement for sewage treatment than have the harmful bacteria.

Filthy conditions along the waterfront of ocean and bays, where bathing is indulged in, undoubtedly furnish the most urgent reasons for cities to install treatment plants, every effort being made to maintain unimpaired and attractive beaches. While dilution is much the less costly method of disposal, as civilization progresses, the people demand better conditions

*Manager of Operations, San Diego.

and apparently are willing to pay the price. The engineer can design and build works to meet any condition, but reason must apply to expenditures.

Sedimentation as a process affords one of the best and cheapest of procedures for removing solids. By sedimentation it is possible to remove from 50 to 75% of the total suspended solid matter. There are many different types of sedimentation tanks, many of which have real merit and have many installations to their credit. The present status of sedimentation is now better than ever before, on account of improved and satisfactory methods for removing sludge and digesting it separately.

In 1909 two treatment tanks were installed in La Jolla, one between the present site of the Casa Manana hotel and the beach, the other farther south. The south tank was built at right angles to the shore line and about two-thirds of the structure was in sight. There were numerous complaints, and the people tributary to the tank paid to have a new tank constructed parallel to the shore line and out of sight except the manholes; the old tank to be destroyed. Since it went into commission no complaints have been registered. Both tanks are of the Cameron type, and have given excellent service, although they have had little if any attention.

At the present time we are constructing a tank on the bay side of Pt. Loma, there being one of the same type at La Playa, which has been in service some three years with no complaints, though close to a built up section. These tanks are of the hopper bottom type and are built to allow for 1.5 ft. depth of scum, one hour detention period, and a sludge capacity of 1.5 cu. ft. per capita; the sludge to be discharged at frequent intervals upon outgoing tides.

Plans have been prepared for a plant near the foot of 32nd St., in San Diego, that are worthy of note. The sewage is to be run by gravity to a point near the bay shore and pumped from there to two clarifying tanks 60 ft. in diam. The detention period is one hour, and approximately 95% of the settleable solids is to be removed in that time; the effluent to be discharged into the outfall. A mechanical squeegee, consisting of four radial arms with plows, is set at an angle. The motor and driving equipment for this mechanism is housed in a stucco building supported on a truss over the center of the clarifier. The incoming sewage flows into an influent trough and thence through five ports into the clarifier tank. The sewage flows horizontally

over a weir into a collecting trough on the opposite side of the tank; the solids settle to the bottom of the tank and are swept to the central collecting cone by means of the mechanical squeegee. This mechanism revolves continually, but very slowly in order that sedimentation be not disturbed. It makes but one revolution every seven minutes, so the wear is negligible. The sludge is to be pumped daily from the clarifier into the digester; an electrically operated diaphragm pump being provided for this purpose. The digester tanks are four in number, 22 ft. deep, 40 ft. in diam., and covered.

Sludge digestion is a bacterial process and it has been learned that the digestion of fresh sludge is hastened if it can be mixed with partly digested sludge in which the particular bacteria which cause digestion are abundant. For this reason, the digester is equipped with a mechanical stirrer. Near the top of the tank are radial pipe with ports into which the incoming sludge is deposited. As the mechanism revolves, these troughs distribute the sludge over the entire surface of the tank. The tanks are so arranged that it is possible to pump from one tank to another. This makes it possible to seed a tank that is not digesting properly from one which is. The sludge is drawn off at the bottom of the tank from a central cone through a pipe to the outfall pipe. When it is desired to draw off sludge from the digester the mechanism is started. The lower arm of the mechanism forces the digested sludge from about the sides of the central cone, where it passes out. The digester mechanism is only operated when fresh sludge is being pumped in or while digested sludge is being withdrawn. No odors will come from this plant, as all gas is collected and piped to the incinerator. This plant will cost $1,000,000, and it will treat 10,000,000 gal. daily at a cost of approximately $2.00 per million gal.

The sanitary engineer has to sell the idea that sewage plants are not all nuisances. Regardless of the fact that new improvements do away with the objectionable features, the instant you decide upon a location for a plant, trouble starts, and if the civic authorities give heed to all the protests they receive, the plant will never be installed.

Slough Disposal at San Anselmo

By C. C. KENNEDY*

Sanitary District No. 1 of Marin county embraces the watershed area of San Anselmo creek, is from 1 to 3 miles in width and 6 miles in length, and contains 15 square miles. It includes two unincorporated communities, Kentfield and Fairfax, and two sixth class municipalities, Ross and San Anselmo, together with a considerable area of undeveloped hillside territory lying above the thickly populated communities.

The district contains an estimated population of 9000, and is almost entirely suburban residential in character, the only business activity being that necessary to supply the needs of the community.

San Anselmo creek discharges into a narrow tidal slough extending inland 3 miles from the open water of San Francisco bay. Prior to 1920 the untreated sewage from the district discharged into this slough 1½ miles below the head of tidewater, and gross pollution existed from the head of tidewater almost to its outlet end. Although the State Board of Health had quarantined the slough against bathing to minimize the health menace, it continued to be so used, as well as for boating and fishing.

The addition of Fairfax and the upper portion of the San Anselmo watershed area to the district in 1921, increased the area and population of the district more than 25%, and necessitated the construction of a new trunk line sewer to relieve the already badly overloaded and obsolete main sewers. This furnished the opportunity to construct a new outfall line and provide treatment to relieve the existing nuisance and health menace.

After a thorough investigation of the sewage flow and measurement of the total prism in the slough, the State Board of Health approved plans for the treatment plant, which consisted of pumps, Imhoff tanks, sludge beds and chlorination equipment for dosage of tank effluent, with provision for discharge into the slough at a point where thorough diffusion was possible.

The site chosen for the plant is one mile from the mouth of the slough, where due to the projection of a promontory of high land, excellent foundation condi-

*Consulting Engineer, San Francisco.

tions for the plant structures existed. With this location of the plant, the tidal prism above the point of sewage discharge is two miles long, with an average width of 20 ft. and a depth varying from 2 to 8 ft., depending on the tide stage.

On account of the level territory traversed by the outfall lines from the head of the slough to the plant site, it was necessary to provide for pumping the sewage. This provision is met by three 6-in. United Iron Works vertical centrifugal pumps, of the wet well type, with the motors on the pump house floor.

To provide for safety against extreme floods and at the same time insure proper discharge head through the chlorination chamber, the top of the Imhoff tanks is 4 ft. above the ground level at the plant.

The tanks, two in number, arranged for parallel operation, are each 67 ft. long and 22 ft. wide in the clear, with a common middle wall. In each tank are two flowing-through chambers, each 7 ft. wide and 9 ft. deep to the slot, with 45 degree slopes to the slot opening. The tanks are comparatively shallow, with three hoppers. They were not designed for reversal of flow, but the depth and capacity of the hoppers were varied in proportion to the amount of solids settling in the three successive twenty minutes of the theoretical hour's detention period. The deepest hopper is 19 ft. 3 in. from the water surface and 10 ft. 3 in. below the slot. The shallowest is 17 ft. 3 in. from the water surface and 8 ft. 3 in. below the slot.

Provision was made for chlorination by installing a Wallace & Tiernan, Type A, direct-feed chlorinator of 75 lb. daily capacity, with a dosing box in the effluent line. In the original plan of operation it was the intention to sterilize the sewage during the bathing season, which was also the season of minimum stream flow. The tremendous hydrogen sulphide content of the water, however, has made the continuation of chlorination impracticable from the economic standpoint.

The plant has consistently given good results, particularly during the past six years, during which time it has been under the supervision of the present manager of the district, D. E. Perry. Typical analyses show solids on Gooch filter reduced from an average of 620 p.p.m. for entering sewage, to an average of 193 p.p.m. for the effluent—or a reduction of 70%—while the b.o.d. is reduced from an average of 238 p.p.m. for the entering sewage, to an average of 178 p.p.m. for the effluent.

With an average dry-weather sewage flow of 1,000,000 gal. daily, which corresponds to the strength of sewage above given, a dilution of 20 times is assured in the tidal prism alone, without taking into consideration the interchange with bay waters.

With this plant all evidence of gross pollution has been eliminated throughout the length of the slough; very little sludge banking has occurred in the channel, and at all times there is residual oxygen in the water of the slough.

Ocean Outfall Experiments

By A. M. Rawn*

Certain fairly well defined laws appear to control the dilution of sewage or fresh water when discharged into a body of water which has the salinity of ordinary ocean water. By trial and experiment, certain relationships which exist between the depth, direction, and quantity of discharge of the sewage jet, and the rapidity with which the sewage water absorbs salt water or is absorbed into it, are fairly well estab-

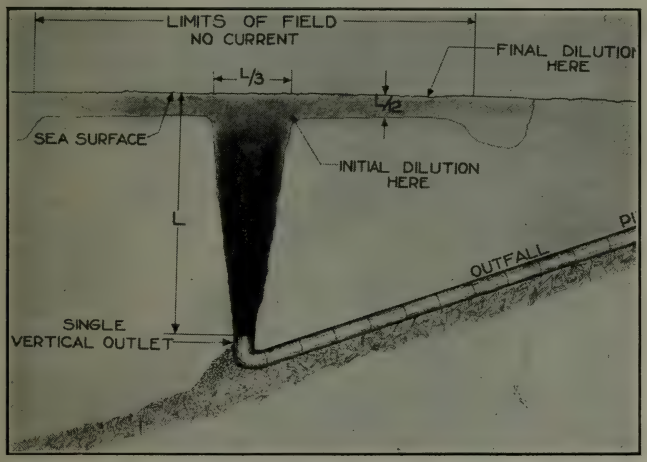


Fig. 1. Behavior of a jet of fresh water discharging vertically in salt water.

lished, and have been set out in analytical form by engineers of the Los Angeles County Sanitation Districts in a discussion published in the proceedings of the American Society of Civil Engineers for May, 1929.

Sewage discharged below the surface of ocean water will, because it is lighter than the salt water, tend to rise immediately to the surface of the salt water; this action following the natural law of gravity. The rapidity with which it rises from the larger outlets is evidenced by a boiling field of sewage usually appearing over the outlet.

Sewage discharged from an outlet pointed directly upward will rise in the form of an inverted cone, the cross section of the cone expanding as it nears the

*Assistant Chief Engineer, Los Angeles County Sanitation Districts.

ocean surface, and the diameter of the base of the cone at the surface being equal to about one-third of the distance from the point of discharge under water to the ocean surface. Sewage discharged horizontally

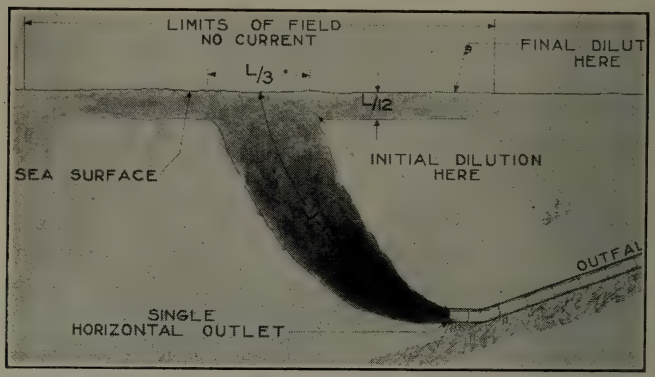


Fig. 2. Behavior of a jet of fresh water discharging horizontally in salt water. The path of the rising water is a cubical parabola. This type is more efficient than the vertical outlet because the longer path to the surface increases the initial dilution.

under sea water will rise to the surface of the sea water along a path resembling the curve of the path of a stone thrown horizontally, except that the curve is inverted. For this case, as before, the cross-sectional area of the curved sewage column or cone expands as

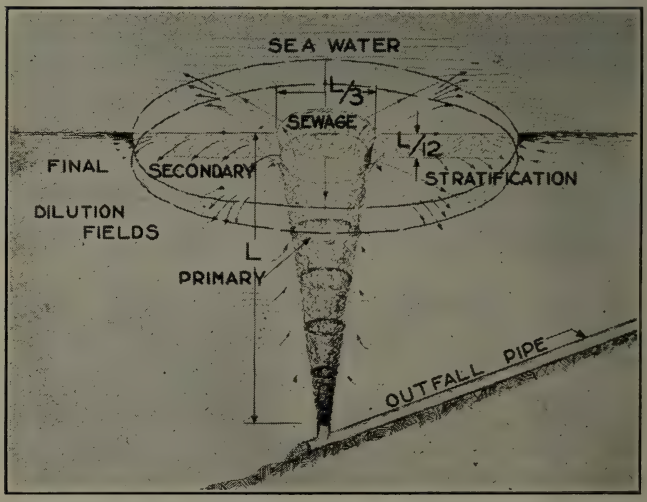


Fig. 3. Diagram illustrating the progressive dilution of the sewage as it rises to the surface of the salt water, and then spreads laterally. Dilution is more rapid in the rising column than in the spreading field, because in rising, the velocity being greater, there is more agitation and it is surrounded on all sides by salt water. In the spreading field the surface of contact is confined to the bottom.

the surface of the salt water is approached, and the area of the column or cone at the salt water surface is equal to about one-third of the length of the path traveled from the outlet to the surface.

During its rise from the outlet to the ocean surface, the sewage obtains what is termed its initial dilution. By this is meant its first mixture with salt water before it comes into sight at the ocean surface. This dilution remains constant for uniform conditions of discharge.

As soon as the mixed sewage and sea water has reached the ocean surface its tendency is to spread

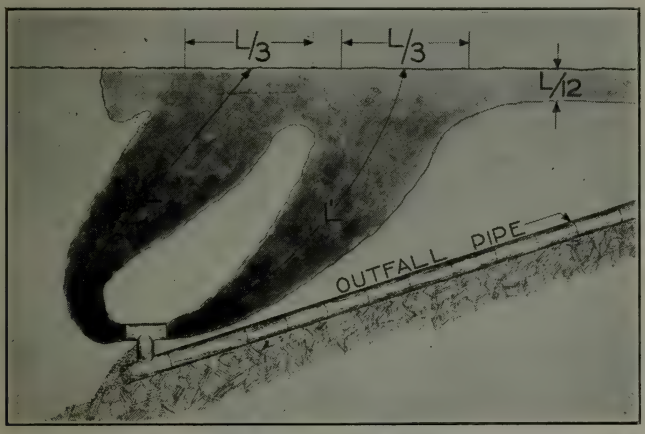


Fig. 4. Behavior of two horizontal jets in a strong current of sea water. The actual lengths of path from the outlet to the surface will be different if referred to the stationary outlet, but when referred to a point moving with the salt water, each will be equal to the length of path in calm water. A current in the salt water promotes dilution only when it becomes strong enough to create agitation. The field will travel against the current until the velocity of the field equals that of the current regardless of the dilution at this point. When the velocities become equal, the surface water will be drawn under and travel with the ocean current.

laterally over the surface in all directions. During the process of spreading, it mixes with sufficient sea water to give it what is termed its final dilution. The term stratification is used to define the action of the mixed sewage and sea water floating on top of the ocean water. It does this because it is lighter and, following the law of gravity, it continues to float until such time as it has mixed with sufficient sea water to so increase its specific gravity that it will mingle intimately with the sea water underneath. The thickness of this floating sewage field remains fairly constant and is equal to about one-half of the distance from the sewage outlet to the ocean surface.

Dilution is most rapid during the rise of the sewage from the outlet to the ocean surface and is dependent upon the surface area of the rising column or cone of sewage exposed to the surrounding sea water. Thus it depends upon three factors, depth, direction, and quantity from a given orifice or outlet; and because initial dilution is such a strong determining factor in the field area these factors should be carefully considered in the design of an outlet.

To obtain high initial dilution with a given quantity of sewage and a given depth of sea water at the

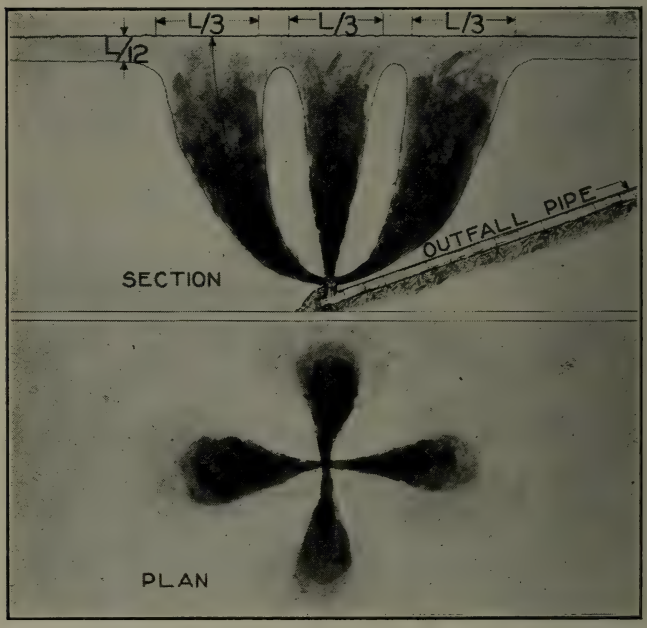


Fig. 5. Behavior of a 4-outlet diffuser. The division of the sewage into several jets results in the increased dilution due to the smaller quantity in each, but if too many jets are employed they will interfere beneath the surface and decrease the area in contact with salt water. Except in very shallow water, not more than six outlets should be used, and in very deep water, not more than four.

point of discharge, it is advantageous to discharge the sewage from the outlet laterally, as nearly horizontal as possible, thus increasing the length of column or cone. The use of multiple outlets is advantageous, but it is necessary to avoid the error of so spacing them that the rising columns of sewage will mingle or conflict before reaching the ocean surface. Should the columns merge below the ocean surface, the surface area of the columns in contact with the

clear salt water is reduced and the initial dilution correspondingly decreased.

The benefit of multiple outlets is well demonstrated by experience with the new Long Beach city outfall. Following the sanitation districts' study of the behavior of sewage in sea water and the efficiency of multiple outlets, Long Beach engineers placed over the new Long Beach outlet, discharging into the harbor entrance, a four outlet diffuser cap. Prior to placing the cap, and while sewage was being discharged vertically upward from a single outlet, a bacteriological survey showed an area of 342 acres

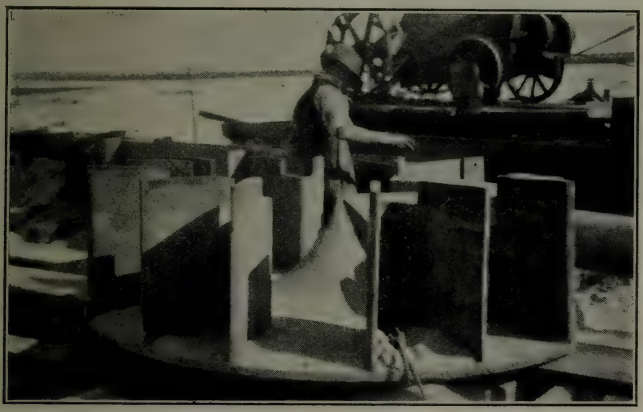


Fig. 6. A cast iron diffuser used on the outfall at Long Leach. The use of this diffuser reduced the size of the sewage field to one-third its former size.

polluted to 100 B. coli per c.c.—six surveys following the erection of the cap showing an average of 127 acres contaminated to the same extent. The 10 B. coli areas are not compared because the 10 line extended beyond the limits of the first survey.

The importance of initial dilution is demonstrated by a comparison between the old Long Beach outlet and the present Hyperion outlet. The former, with a field approximating 50 acres per cubic foot per second for an initial dilution of 2 (1 part of sewage water to 1 part of sea water), the latter with a field approximating 5 acres per cubic foot per second for an initial dilution of 14 (1 part sewage water to 13 parts of sea water). Other conditions being equal, it can be said with a fair degree of certainty that the area of the sewage field varies inversely with the square of the initial dilution.

Upon reaching the surface of the salt water, the mixed sewage and sea water, as has been stated,

spreads laterally, if unrestricted, in all directions, and during this spread, dilution continues, but much more slowly than during the period of initial dilution. It continues to float, or stratify, until the specific gravity of the mixed sewage and sea water is as nearly equal to that of the clear sea water underneath, that the two fluids mingle; the outer limits of the field being marked by the location of such intermingling.

The effect of an ocean current is to elongate the field in the direction of the current. Those who are familiar with outlets along the Pacific Coast have probably observed, at times, the elongated segmental shape of sewage fields. This is due to the fact that the sewage in spreading over the ocean surface pushes its way against the current as far as it has the power to do so, and there stops in a well defined visible line, the force of the spreading sewage and the force of the ocean current being equalized at such a line. The spread of the sewage is, however, greatly facilitated in the opposite direction and consequently moves out rapidly with the current, still spreading laterally across the current at all times.

This action of the two forces results in a roughly segmental field, which can be mathematically shown to occupy about the same area as a circular field resulting from discharge into calm, quiet water. The distance of travel from the outlet is, however, much grater, being the sum of the velocity of the ocean current and the velocity of the spreading sewage combined. This feature is to be reckoned with in design.

Discharge of sewage into a narrow confined channel will result in a larger field than though the sewage were discharged into the open ocean. The sewage field being approximately constant in depth on the ocean surface, it must absorb sea water along its plane of contact with the pure sea water underneath, and, whenever the depth of the field equals the depth of the sea water, dilution will cease until a further supply of sea water is available. It must, therefore, move out from its shallow location to where it can again find its stratum above the sea water, in order that it may continue dilution. It must be remembered also that it will probably move out in a long streamer, because it has lost its initial lateral velocity, and will tend to remain in an elongated field rather than to spread laterally.

A choppy, rough sea will undoubtedly assist in mixing the sewage and sea water, provided the stratum of mixed sewage and sea water is not too thick. Sea

traffic will also in some measure increase dilution, although this factor is not very important. The type of pre-treatment of the sewage prior to discharge into the ocean has important bearing upon the field appearance and, if it is possible to remove a large percentage of the grease from the sewage, such should most certainly be done, in order that the visible, sleek field may be minimized.

The criterion for design at a given outfall site should probably be a calm sea surface at lower, low tide coupled with the peak flow of sewage and the most pronounced effective ocean current observable at the selected site. These three combined, probably will result in the maximum field obtainable or the maximum distance of sewage travel from the outfall site. By careful observation of the direction and intensity of the ocean currents, the available depth at the outfall site, proximity to shores which would suffer from contamination as well as proximity to open ocean waters, it is felt that the designer may equate the factors of depth, direction, and quantity so as to erect an outfall with a field of pre-determined area and distance of travel.

Concrete Pipe Outfall Sewer and Pumping, San Rafael

By H. K. Brainerd*

I have been asked to tell you something of the sewerage system in San Rafael from the early days up to and including our latest acquisition of concrete gravity and pressure lines and a pumping plant.

San Rafael was incorporated as a town in 1874, the first meeting of the Board of Trustees being on April 9, 1874, after which time records are more or less complete.

At one of the earliest meetings we find an authorization to survey the town to determine the center lines of the streets and the location of sewers.

Digressing for just a moment, we also find that in May, 1874, the committee on rooms made a verbal report recommending the renting of rooms of A. C. McAlister over his bar, a location which may account for the numerous meetings that were held later.

Inasmuch as there seems to be a question as to the time when concrete was first used for sewers, a reference here to its use in San Rafael may be of interest to you.

On June 30, 1874, we find "It was moved and seconded that the P. Martin North Beach Cement Pipe be adopted as the kind of pipe for the construction of sewers in said town", and that in July, 1874, the bid of J. J. Conlin was accepted for building sewers, and the map of the Townsite of San Rafael, dated 1875, shows a considerable footage of that type of pipe.

Later extensions were made of vitrified clay pipe, sometimes apparently after considerable thought as to sizes; and at other times the system seemed to just grow.

Sewage originally was dumped into San Rafael creek close to the town limits, and proved in time to be a nuisance; so that in 1892 it was determined that a pumping plant was the proper solution of the difficulties. This system was composed of a reception tank, a centrifugal pump operated by a steam engine,

*City Engineer.

and a steel pressure line along the toll road to San Quentin, discharging into San Francisco bay.

This system also proved objectionable, not only on account of pump troubles, but also because of the rapid consumption of wood under the boiler, and because within a comparatively short time leaks developed along the pressure line, resulting in a disconcerting spray on the passerby.

In fact, there must have been a considerable number passing by, for in November 1898, when the system was about six years old, the contract was awarded for an entirely new outfall sewer, this time of the gravity type, at a cost of $25,000.

Undoubtedly considerable discussion developed as to the material to be used in the construction of this sewer, for I find a reference to an amendment to the plans and specifications, changing the size from 24 to 30 in., and selecting the redwood stave type.

The point of discharge was located on the shore line of San Francisco bay, approximately midway between the mouth of San Rafael creek and San Quentin point. The pipe was laid across a reclaimed marsh to the toll road leading from San Rafael to San Quentin, thence along the toll road to San Rafael; a total distance of 8400 ft., the fall being 3/8 in. per 100 ft.

The pipe section was formed of nineteen staves, carefully milled on all sides from perfectly clear 'sinker' redwood, the end of each stave being trimmed off square and slotted to receive a brass tongue. The pipe was banded every 12 in. with a 5/8-in. steel bolt, tightened against a malleable iron saddle, and was built in place.

Because of the flat grade, and to get the selected maximum velocity of 3 ft., a flushing basin covering three acres was also provided, and originally used daily about two hours before the lowest tide.

This system remained in use for 28 years, being replaced by our present system, which I shall describe to you.

The defects which required still another replacement are briefly as follows:

Approximately 17% of the area of San Rafael is below elev. 20 ft., and some twenty blocks are not much higher than high tide level. During the higher period of the tides, sewage backed up into this low level area at all times of the year. During storms a large amount of extraneous water was introduced into

the system, causing the spilling of sewage upon the streets through certain manholes.

The sources of storm-water supply can probably be rated in the following order:

1. Roof drains connected to the house sewer.
2. Surface water leaking into house trap vents.
3. Ground water infiltration through open joints and porous pipe.
4. Leakage through manhole areas.

A recent survey disclosed that the roof drains from 233 buildings, about 11% of the total, were connected to the sanitary system.

As the wood-stave sewer aged, the bolts rusted away, allowing the sewer to deform in an elliptical shape and finally fail. As the sewer was entirely cov-

San Rafael Pressure Outfall Sewer Along San Rafael-San Quentin Road; Showing 21-in. Hume Pipe Before Joints Have Been Filled.

ered, no attempt was made to repair it until leakage appearing on the surface indicated serious trouble. Many times, replacing bolts extended the life of the sewer, but finally the constantly recurring bad breaks required some sort of renewal. This was generally made with Armco corrugated iron pipe, although some repairs were made by replacing the arch with reinforced concrete.

The deformation resulted in a lessened carrying capacity; and due to faulty gradient, sludge accumu-

lated both in the wood stave outfall and in the low laterals, creating bad odors.

For the benefit of those who may be considering wood-stave pipe for any purpose, I may state that most of the pipe, insofar as the wood was concerned, was in excellent condition, and that had some better choice been made in the bolting material, I believe the line would have had an indefinite life, the length of which would have been determined by the bolting material.

This brings us up to the studies made for our present outfall sewerage works.

The first problem was to settle the seemingly never-ending argument of whether to use the gravity system or to pump. This time, after a conference with the State Bureau of Sanitary Engineering, it was determined to gravity the sewage to a pumping station and then pump to San Francisco bay.

I am very glad to acknowledge the active and helpful co-operation of the Bureau of Sanitary Engineering in all of our preliminary investigations.

Colorometric velocity tests were made in the wood-stave sewer both during the period of apparent normal flow and during storms. Making an assumption as to the cross-section of the sewer, the following quantities were assumed:

Average daily dry season flow in 1928—1,375,000 gal.

Maximum daily dry season rate—1600 g.p.m.

Minimum daily dry season rate—600 g.p.m.

Maximum daily dry season rate in 1948—2700 g.p.m.

An observed wet-weather flow was approximately at the rate of 5,000,000 g.p.d. A comparison of this flow with others indicated that a capacity of 7,000,000 g.p.d. was more than ample.

Our present system consists of 676 ft. of 21-in. and 978 ft. of 30-in. Hume centrifugally spun concrete pipe, conveying sewage under gravity to the pumping station.

The pumping station is of reinforced concrete on piles, and houses the following units:

No. 1 pump, nominal capacity 2000 g.p.m., against an 18.6-ft. head, and driven by a 15-hp. motor.

No. 2 pump, nominal capacity 3500 g.p.m., against a 30-ft. head, and driven by a 40-hp. motor.

No. 3 pump, nominal capacity 500 g.p.m. against a 31.5-ft. head.

Pumps 1 and 2 are driven by Westinghouse motors, and pump 3 by a Sterling engine fueled by illuminat-

ing gas; all three being full automatic in operation and controlled by float switches. The pumps were furnished by the DeLaval Steam Turbine Co., the automatic control for the motors by the Westinghouse Electric & Mfg. Co., and for the gas engine by the Cutler-Hammer Mfg. Co.; the gas engine and its control being furnished as a unit by the King-Knight Co. of San Francisco.

The reason for the gas engine installation is because that while San Rafael is served from two separate power sources, there have been power failures, and as the grade of the pressure discharge line is higher than the grade of the incoming gravity line, it is quite essential that an auxiliary be available.

In addition, the capacity of this pump is such that it will take care of the maximum probable stormwater.

The order of the operation is as follows:

Sewage rising in the sump trip floats with No. 1, starting the 2000-g.p.m. pump. At the present time this pump operates for approximately 14 min. per run, and runs 13 or 14 times per day, delivering as high as 2600 g.p.m. without excessive horsepower input.

As soon as stormwater reaches the sump in excess of the capacity of this unit, pump No. 2 will operate, No. 1 remaining on only until No. 2 gets up to speed. Should No. 2 be unable to handle the input, No. 3 is then available. In addition, the capacity of this pump is such that it will take care of the maximum probable stormwater.

The output from the electrically driven pumps passes through a Bailey orifice and is recorded on the 24-hr. chart of the integrating-recording Bailey units. The guaranteed pump efficiencies at the design head in all cases were 80%. These were somewhat in excess of the specification requirements, but have been reached in the case of the two electrically driven units; but are untested in the case of the gas engine, since the output from this unit does not pass through the meter.

Pumps No. 1 and 2 both discharge through a manifold into a 21-in. Hume centrifugally spun concrete pipe extending along the toll road and across a reclaimed marsh to San Francisco bay, a distance of 6800 ft. Pump No. 3 discharges into an 18-in. Hume pipe extending along the toll road to San Rafael creek. a distance of 1450 ft.

Original soundings disclosed fairly well that the ground through which the pipe was to be laid was

rather unstable being mostly a black silt; and inasmuch as a great deal of the pipe was to be buried in the shoulder of the state highway, considerable thought was given to the material of which the pipe was to be made.

A check on the experience of others using concrete pipe, plus a substantial saving in cost, decided us in favor of the pipe manufactured in Oakland by the Bent Concrete Pipe Co. (now the American Concrete Pipe Co.)

Because of the character of the ground, practically all of the pipe was laid on a redwood cradle. The cradle was made as follows: Two 2by12-in. redwood plank runners were laid on 2 by 8-in. sills in the mud. Upon the planks, and at right angles to them, were laid 3 by 4-in. ties at 4-ft. centers, all well spiked and laid uniformly to form the bed of the pipe.

Joints were formed of neat cement, barely moist, and calked in with ordinary caulking tools. All joints were finished with similar material on the inside after the pipe had had a chance to settle.

The specifications required the pipe to be tested under an internal water pressure equal to 125% of the maximum pressure under which the the section was to operate, the permissible leakage being 200 gal. per inch of diameter per mile in 24 hours. All pipe passed this test well within the allowable limits.

The system design presented some unusual and interesting problems, and I had the pleasure of associating with Charles Gilman Hyde, Professor of Sanitary and Hydraulic Engineering, University of California, in their solution.

The work was performed under the Acquisition and Improvement Act of 1925, by W. J. Tobin of Oakland, the contract amounting to $87,392. We found this act to be very workable throughout, and the bonds, drawing 5% interest, were readily marketed.

Bay Disposal and Chlorination

By R. L. Patterson*

The city of Newport Beach is almost entirely a residence city and summer resort situated on Newport bay, in Southern California. Its permanent population is 4500, but during the four summer months the population increases to 10,000, and 20,000 on week-ends and holidays. About 60% of the area within the city is sewered. The present sewer system is divided into two separate systems. One system provides for Balboa island and the other provides for the sand spit about 3 miles long lying between the bay and the Pacific ocean.

The system along the sand spit will be discussed in this article. This sewer system includes 11 miles of cement pipe, from 8 to 20 in. diam. The topography is such that very flat grades are necessary. The entire sewered area, with a length of about 3 miles and a width of 700 ft. to ½-mile in width, has an elevation 7 to 12 ft. above mean lower, low water. The sewage is lifted at three different points by pumps. Pump station no. 1 is at the Imhoff treatment tank. Station no. 2 is 7400 ft. from station no. 1. Station no. 3 is 6400 ft. from station no. 2.

The Imhoff tank and pumping station no. 1 are adjacent to each other and along side of the state highway 600 ft. west of the Newport beach-Santa Ana road. This location was selected primarily to avoid contamination of ocean water anywhere along the 3 miles of beach front which is used extensively for bathing. This site, at the time of construction in 1922, was remarkably well isolated, being cut off from the city by the Santa Ana river and 1000 ft. of marsh land, and cut off from the only public road in the vicinity by a high railroad embankment. There was not a dwelling within 1000 feet. With the growth of the city, the dredging of the bay, and the construction of the state highway along side of the Imhoff tank, its location is now very undesirable. The tank is heavily overloaded, the retention time in the flowing through chamber being only 45 min. during the peak flow.

The effluent from the Imhoff tank is discharged into the former channel of the Santa Ana river, where

*City Engineer, Newport Beach.

the channel widens out into Newport bay. Shortly after construction of the Imhoff tank, the Santa Ana river was cut off from entering Newport bay, and a new outlet constructed to the ocean. The two high tides each day provide a large quantity of diluting water with which the sewage will mix; the range in tide level being 5.1 ft.

The amount of sewage treated by this plant is 400,000 gal. daily during the wintertime and 780,000 gal. during the summer months. Owing to the low velocities and the intermittent operation of the pumps, the sewage reaches the Imhoff tank in a somewhat stale state.

Chlorination for Odor Control—The production of offensive odors commonly associated with sewage treatment plants was one of the vexing problems confronting the city of Newport Beach at its Imhoff tank. There was imperative need of relief from the odors from the Imhoff tank, as numerous complaints had been made by property owners in the vicinity of the plant and from motorists passing along the state highway. R. F. Goudey, resident engineer, Los Angeles, State Department of Public Health, suggested that chlorination be tried out. Goudey was carrying on experimental work in chlorination for odor control on the Orange County-Santa Ana outfall sewer. The city, in cooperation with L. G. Sovulewski of the Wallace & Tiernan Co., Inc., carried on experimental work from July 12, 1928, to September 1928. From the results obtained, the city on September 28, 1928, purchased a Wallace & Tiernan chlorinator, and is now regularly chlorinating for odor control in its Imhoff tank.

Field Experiments—First, samples were taken of the sewage, and the average amount of hydrogen sulphide was determined before chlorination at the following points:

	Average Hydrogen Sulphide p. p. m.
Manhole, 1 block above pump sta. no. 3	1.7
Pump station no. 3	3.4
Pump station no. 2	4.0
Easterly of station no. 1	7.5
Manhole, 300 ft. above pump sump, station no. 1	9.5
Equalizing basin	6.5
Effluent, Imhoff tank	7.9

The foregoing samples show that starting with the upper manhole, there was a gradual increase in the amount of hydrogen sulphide up to the effluent from

the treatment plant. Attention is called to the decrease in the amount of hydrogen sulphide in the equalizing basin. This was due to the liberation of the gases by a 3-ft. drop from the end of the discharge pipe.

A chlorinator was installed at pump station no. 2, as the experiments on the Santa Ana outfall sewer showed that the chlorine demand would be less by destroying the sulphate splitting organism before hydrogen sulphide is produced in large quantities. The following tests were taken, using a dosage of 45 lb. and 100 lb. of chlorine per 24 hr.

Date	Chlorine dose per 24 hours	Time of run Pump Sta. No. 2, unchlorinated.	M.H. 300 ft. above Station No. 1. Hydrogen p. p. m.	Equalizing basin Sulphide p. p. m.	
Aug. 2	45	24 hr.	4.4	4.6	3.7
Aug. 5	45	4 days	4.0	5.7	4.6
Aug. 23	100	24 hr.	3.9	3.6	2.7
Aug. 24....	100	36 hr.	4.0	4.2	2.8

The estimated flow at this point was 45,000 gal. per 24 hr. Using a chlorine dosage of 45 lb. per 24 hr., which was equivalent to 13.2 p.p.m., reduced the hydrogen sulphide from an average of 6.5 to 4.6 p.p.m. in the equalizing basin of the Imhoff tank. Using a chlorine dosage of 100 lb. per 24 hr., which was equivalent to 30 p.p.m., reduced the hydrogen sulphide to 2.8 p.p.m. in the equalizing basin.

The odors at the Imhoff tank were reduced, but not sufficient to prevent complaint, and as the chlorine demand would prove expensive, the chlorinator was moved to the Imhoff tank on September 1.

The chlorine was mixed with the sewage in the pump pit. After experimenting with various rates of chlorine dosages and varying the time of application, it was found by using a dosage of 70 lb. per 24 hr., which was equivalent to 11.7 p.p.m., from 11 a. m. to midnight, that the hydrogen sulphide in the equalizing basin was reduced to 1 p.p.m. and less, and in the effluent from the tank to 2.0 p.p.m. By keeping the hydrogen sulphide content down to 1.5 p.p.m. and below, odors where noticeably controlled at the Imhoff tank, and at the effluent discharge pipe. The tank effluent at no time contained any r e s i d u a l chlorine. Prior to chlorination, the odors from the tank between midnight and noon were not sufficient to cause complaint, so it was not considered necessary to chlorinate during this period. The chlorination at the rate of 70 lb. per 24 hr. was carried on for 10

days. The odor nuisance was considerably improved.

Results of Prechlorination—The Enslow method was employed for hydrogen sulphide determinations, and gave consistent results. However, the best way to judge results is by the number of complaints. Residents in the vicinity of the Imhoff tank stated that the odors were noticeable on a few occasions only since the chlorination experiments were started, and that conditions were greatly improved over the previous summer. A chlorine dose of from 10 to 12 p. p. m. has proved to be sufficient to control the odors.

The chlorine demand was reduced considerably by certain improvements in the Imhoff tank. The sewage from the pump sump was discharged over the top of walls of the equalizing basin and permitted to drop about 3 ft. into the basin, which aided in liberating the gases. The discharge pipe was changed so that the discharge was on the floor of the basin. A baffle gate built of 1 by 4-in. strips 1 in. apart, cut to the shape of the walls, was placed in each flowing through chamber to distribute the flow. The effluent passed over a weir and dropped 2 ft. into a trough leading to the outlet pipe. This drop aided in liberating the gases. The drop was reduced to 4 in. Together with better care of operation of the Imhoff tank, these changes helped to reduce the chlorine demand.

The amount of chlorine used during the winter months averaged 20 lb. per day, and during the summer months 35 lb. per day. When the wind is from the southeast, the chlorination is discontinued, as the land to the northwest of the plant is undeveloped.

The prechlorination of sewage for odor control at Newport Beach has been in use for one year with satisfactory results when consideration is given the small quantity of chlorine applied. The prechlorination of the sewage has in no way adversely affected the function of the tank, if anything, it has improved conditions.

Cost Data for Chlorination.

The capital outlay is as follows:

Chlorinator and appliances	$1525
Building	75
Total	$1600

Cost of Operation
For One Year.

Chlorine, 8050 lb. @ 6½c	$ 523
(Average cost per day $1.54.)	
Water for operation of chlorinator	75
Interest and depreciation on equipment (15% of $1600)	240
Total	$ 838

Cost per day—$2.30.

Bay Disposal—Imhoff tank no. 1, hereinbefore referred to, was completed in 1922, and Imhoff tank no. 2, which serves Balboa island, was completed in 1926. The discharge from both tanks empties into Newport bay. The two high tides each day provide large quantities of diluting water with which the sewage will mix. The effluent from the Imhoff tanks is not treated in any manner at present, but it is planned to use chlorination during the coming summer season.

The discharge of the effluent into the bay has proved very satisfactory up to the present time. Samples of the water in the bay taken during the summer months, show that the condition of the water is very satisfactory for bathing except for a distance of 600 ft. from the discharge pipe from tank no. 1 where the channel is narrow and shallow, and does not allow sufficient mixing of the effluent with the bay water.

With the development of the district in the vicinity of Imhoff tank no. 1, and the increased use of the bay for bathing, it soon will be necessary to provide better treatment of the sewage. The present plans are to abandon Imhoff tank no. 1 and construct a new treatment plant alongside of the Santa Ana river outlet to the Pacific ocean at the westerly city limits.

Sewage Disposal in California

By LEON B. REYNOLDS*

Sewage disposal is defined as 'the act of disposing of sewage by any method', and sewage treatment as 'the artificial process to which sewage is subjected in order to remove or so alter its objectionable constituents as to render it less offensive or dangerous'. We should not use the term 'sewage purification' in most cases, because literal purification is not often accomplished.

The water carriage system for removal of domestic wastes is hardly eighty years old in the United States, and necessarily sewage disposal originated as soon as sanitary sewers were constructed. Sewage treatment is a younger art, dating in its modern form from the establishing of the Lawrence Experiment Station by the Massachusetts Board of Health forty years ago.

Naturally the east has been the scene of the development of methods of treatment designed to improve the effluent before its discharge into streams, whose pollution was growing rapidly worse with increasing congestion of population. During the last 25 years sewage treatment in California has had its development, and during the last 15 years practically all of the plants designed to produce an oxidized effluent have been built.

California now has nearly 300 sewer systems and about 200 sewage treatment plants. Probably only 2 states have a larger number of treatment plants.

Sewage disposal in California is by two methods—discharge into water and discharge upon land. Discharge into water known as dilution, may be into fresh or salt water; the fresh waters used are streams, irrigation ditches, or drainage channels, and the salt waters are sloughs, bays, or the ocean. About 100 systems discharge into fresh waters, 108 into salt waters, and discharge upon land is the method of disposal used by 92 systems.

Of the systems using disposal into fresh waters, 23% discharge untreated sewage; of those using disposal into salt waters, 62% discharge raw sewage; and of those using disposal upon land, 16% discharge untreated sewage. The fact that over one-third of the sewer systems of the state still discharge untreated

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sewage must be a matter of concern to the State Board of Health.

In 23 cases, fresh waters are being polluted with raw sewage. Some of these streams are potentially of value for domestic supplies and some are actually being so used, while others are of value for irrigation, and others are drainage channels whose waters might be used. These conditions are far from satisfactory and cannot go on indefinitely; the only question is when will these communities come to a realization of the dangers involved and the reasonableness of keeping our waters unpolluted.

In 67 cases, raw sewage is being discharged into salt waters, mostly bays or sloughs. Ocean outlets may be satisfactory if their outlets are located intelligently with reference to depth of water, ocean currents, prevailing winds, distance from bathing beaches, etc. Outlets into bays are less satisfactory because the depth of water at the point of discharge is usually not great and circulation is frequently ineffective; sludge deposits on tidal flats are liable to form, causing offense to sight and smell. Outlets into sloughs are frequently extremely unsatisfactory because of the lack of flushing out by tides from below, or by contributions of fresh water from above; velocities of outflow in sloughs in order to secure scour are also important.

As an example of the discharge of sewage into a bay, mostly through sloughs, may be cited San Francisco bay, where 17 communities discharge mostly untreated sewage along the west side from South San Francisco to San Jose. The conditions in some of the sloughs are visibly bad, and sludge deposits are in evidence on tidal flats at low tide; probably no one knows the exact condition of the bay water, nor how effective circulation is actually provided by tides. Several of these cities are actually constructing and others considering, commercial harbor developments, yacht harbors, bay parks, etc. It may be that recreational use of the bay will lead these cities to adopt some less lazy method of sewage disposal than dumping into the nearest slough. One influential man has said that he would like to have a nice boat on the bay but that he doesn't want to put it down in that diluted sewage. It is farsighted policy for such locations to be acquiring suitable land as sites for future sewage treatment plants, and my own prediction is that their actual construction will not be so very far into the future.

Disposal of sewage upon land is a method more used in California than any other state, because of the

lack of diluting water away from the coast, because of the existence of suitable soil, and because the climatic conditions make irrigating water valuable. Five years ago the State Board of Health stated that there were 'no shining examples of sewer farming in California', and presumably this statement is still pretty much true. However, the tendency during the last few years toward better treatment of sewage before discharge upon land, is to be commended, and points toward a more successful reclamation of sewage from the standpoint of use of water. Revenue is now being secured from use of water for pasture or crops in about half the cases of land disposal.

So much for disposal of sewage.

Treatment of sewage before its disposal is now practiced by over 200 cities in California. This treatment varies from the removal of only the largest floating solids to the removal of nearly all the suspended solids and bacteria. In the accomplishments of these results practically all of the methods used anywhere have examples in this state, and there are some 13 major variations in type of plant.

Along our coast there are 7 fine-screening plants primarily for the protection of bathing beaches, there is one fine screen in the interior of the state and three to decrease the load on the remainder of the plant. There are still 87 septic tanks, mostly survivals of the septic tank period 15 to 20 years ago; in most cases there being no further treatment after the septic tank; and many of the tanks are cleaned too infrequently, and the inevitable story will be the abandonment in the relatively near future of most of these tanks for better types of treatment. There are 96 Imhoff tanks which have been built within the last 15 years, about half of which are followed by no further treatment. Great variety in design of tanks, especially in sludge storage space, and great variations in quality of effluent and in water content of sludge, have been observed, and foaming has caused considerable trouble. Of late there has been an increasing tendency toward the adoption of plain sedimentation in Imhoff or open tanks, from which the sludge is removed continuously or frequently to a separate sludge digestion tank, and we now have 13 such plants.

For final treatment of the effluent from sedimentation tanks of some kind we have two main processes; there are 33 trickling filter and 26 natural sand filters. Trickling filters have given general satisfaction if not overworked from inadequate preliminary clarifica-

tion. Natural sand filters involve the use of natural sandy areas with cultivation of the surface.

The first activated sludge plant in California was built 12 years ago and is now abandoned; another was built 9 years ago, but was soon abandoned. The third plant was built 6 years ago, and there are now 7 plants operating and two non-operating. Commercial fertilizer is being produced in one plant, and in the others drying or digestion of sludge has been accomplished without great difficulty. Quality of effluent is very satisfactory.

Chlorination is being practiced in 19 cases to destroy bacteria, which might be a menace to health in a stream or irrigation ditch or near a bathing beach. In four cases chlorine is being used for odor control, resulting in a great improvement in conditions over those formerly existing.

So much for treatment of sewage.

What shall we say of the future? Increasing knowledge on the part of operators of plants, increasing interest on the part of city officials, increasing care used in design of plants, all point hopefully toward the day when the sewage treatment plant will be a place of pride and efficiency. Problems remain to be solved, particularly those occasioned by the presence of industrial wastes, and our governor's failure to sign the recent bill for sewage and wastes disposal research is regrettable; however, the need for such studies still exists and the matter will not be allowed to drop. A method of securing revenue for operation and maintenance of sewers and sewage treatment plants through a sewer rental, would also be welcomed by certain cities, and a permissive law allowing such charges was introduced in the last Legislature but was not passed.

All in all, the future of sewage disposal in California is brighter than it has been for many years.

For much of the information in this introduction I am indebted to C. G. Gillespie, chief, Bureau of Sanitary Engineering. I now wish to show you some lantern slides of California plants. Members of the C.S. W.A. may have visited some of the plants shown, but the pictures may be interesting to the members of the Engineers' Section of the League, who are meeting with us.

Abstracts of Papers Read at Sanitary Engineering Section, School of Citizenship and Public Administration, Short Course, University of Southern California,

June 17-22, 1929

The following abstracts were taken from papers arranged for by the Education Committee of the California Sewage Works Association and presented by the authors noted.

The Carrying Capacity of Sewers—By Fred C. Scobey, senior irrigation engineer, U. S. Department of Agriculture.

Conduit efficiency is measured by the amount of water carried. The larger the conduit, the steeper the slope, and the smoother the conduit, the more water. Modern conduits carry 30 to 50% more water, size for size, shape for shape, and slope for slope, than was feasible 30 to 40 years ago. A given surface is more easily attained in precast concrete or in tile-lined concrete pipe than in monolithic construction. Brick sewers are probably a thing of the past. Experimental data indicate that sludge may be considered the same as water up to a solids content of 10% sludge. From then on loss of head increases over that of unmodified water. Kutter, Manning, Williams-Hazen, and Scobey's formulae are applicable under varying conditions. In general the value of n for sewage should be taken as 0.002 added to those for water; for example, Grade A concrete pipe for which n=0.011 is used for water would be figured n=0.013 for sewage.

Use of Centrifugal Reinforced Concrete Pipe and Specifications for its Manufacture—By N. D. Whitman, engineer, American Concrete Pipe Co.

Centrifugal reinforced concrete pipe is now in general use throughout the world, its use being widespread since its introduction fifteen years ago. The process of manufacture utilizes centrifugal force to produce a dense uniform product with excess water and entrained air forced out. It is used for water lines, sewers, culverts, pile protection, well casings, caissons, etc. For sewers, storm drains, and culverts, 1 part ce-

ment to 5 parts aggregate are used. For pipes less than 24 in. diam. reinforcement is placed in the center of the shell. For larger pipe an elliptical or two-chord form is used, the pipe being plainly marked so the minor axis may be kept vertical. For heavy earth loads additional reinforcements are necessary. Materials, workmanship, jointing, testing, and backfilling must all be according to specifications.

Trench Loadings and Sewer Pipe Foundations—By C. R. Compton, office engineer, Los Angeles County Sanitation Districts.

During the past few years some concern has been aroused as a result of sewer pipe failures. Much has been done by engineers to eradicate this trouble. Marston's experiments at Iowa State developed the well known formula $W = C\ w\ B^2$

W=Load on pipe in ditch in pounds per lineal foot.
C=Coefficient of loads on pipe in trench.
w=Weight of ditch filling material in pounds per cu. ft.
B=Outside diameter of pipe plus 16 inches.

Allowable cover depths for vitrified clay and machine made concrete pipe computed from the above formula with pipe sizes ranging from 8 to 30 in. diam. are found to average 10 to 11 ft. If supported on a concrete cradle or bedded in sand, the pipe in trench at or near the critical depth may be considered safe. The use of double strength pipe in place of standard has resulted in safer structures, and the cost of increasing wall thickness is probably less than that of taking unusual precautions in foundations.

Sewage Pumps—By A. Hollander, chief engineer, Byron Jackson Pump Co.

Pumps considered in this paper are centrifugal sewage pumps handling raw sewage from which cans, sticks, etc. have been screened, in sizes for large buildings, small cities, and large cities. Pumps are either horizontal or vertical. The first requirement is that they be non-clogging. A single suction, overhung, closed impeller having only channels and no vanes, has been found the most satisfactory type. The single port impeller, instead of two-port, is more liable to vibration, being hydraulically unbalanced. The minimum port advisable is 2 in., although 1½ in. has been satisfactory in some cases. Heads up to 100 ft. are satisfactory in one pump, but lower heads are desirable and imperative for small sizes. For maximum size solids, mini-

mum impeller passage should be 80% of the pump size, but this may be diminished to 60% for larger and higher head pumps. An important rule is that ports should not get smaller from inlet to outlet, to avoid possibility of solids wedging into the smaller opening. Reliability of operation and exclusion of possibility of clogging require sacrifice of efficiency, which does not mean less economy, if by best economy we understand least total expense in depreciation, power, attendance, and repair. Efficiency will vary from 50 to 66% according to size, capacity, and head. Bearings and shafts have to be heavy to avoid vibration. The horizontal and vertical designs each have advantages. The horizontal design is easily assembled, bearing construction is simpler and more reliable, has a single base for pump and motor. The vertical type takes less space and permits motor to be placed above the pit, thereby excluding damage from flooding, and is the only one suitable for wet-pit arrangement. The case and cover are made of cast iron, impeller of bronze, and shafts of hardened steel such as nitralloy or stainless steel of high carbon. Direct motor drive is general. In case of possibility of failure of electric current, gasoline engine units are used. Storm sewage pumps are generally special water pumps, and with proper grids to exclude large branches, etc., are found satisfactory. Efficiency and reliability are deciding factors in sewage pumps.

Sedimentation of Sewage—By A. M. Kivari, sales engineer, The Dorr Company, Los Angeles.

Sewage under quiescent or retarded flow conditions will drop its solids, the degree of clarification being dependent upon the character and strength of the sewage, temperature, and time. If it be assumed that a satisfactory effluent can be produced with a one-hour detention period, the size of tank necessary may be computed from the formula V= O x A when V=volume of tank, A=area of tank, and O=overflow rate, or depth to which solids will settle in one hour. As an illustration, if the overflow rate be taken as 6 ft., and the flow 46,500 gal. or 6200 cu. ft. per hour, then the area of tank required would be

$$\frac{V}{O} \text{ OR } \frac{6200}{6} = 1033 \text{ sq. ft.}$$

The tank indicated is 32 ft. sq. with a water depth of 6 ft., with, of course, provision for sludge storage and

removal. In Dorr clarifiers with rotating mechanism for removing sludge, results for five plants showed settleable solids removal of 93.3 to 98.5%, suspended solids 43.6 to 76.1%, and biochemical oxygen demand removal of 13 to 35.7%.

Sewage Treatment Methods and Costs—By Harry N. Jenks, sanitary engineer, Associate Professor of Sanitary Engineering, Iowa State College*.

Disposal by dilution has a definite field of usefulness. The danger lies in failing to realize its limitations. A river actually serves as a very extended sewage treatment plant, which not only makes sewage less offensive by virtue of dilution, but also induces the same biochemical changes effected in socalled artificial processes. If the public health aspects of a stream do not govern, the oxygen resources determine the treatment requirement.

Disposal by broad irrigation has been used extensively in Great Britain, and in California has proven quite successful under certain soil conditions. The use of chlorine to retard biochemical demand is sometimes helpful.

Mechanical and physical treatment includes screening, grit removal, and plain sedimentation. Screening may be used before dilution, as at Los Angeles, as preliminary treatment ahead of other treatment works and to remove material from industrial wastes. Grit removal is accomplished by reducing the velocity to permit mineral matter, sand and silt to settle, but leave organic matter in suspension. Equipment is now available for mechanically cleaning and removing grit. Plain sedimentation is without rival in cost per ton of solids removed. It relieves loads on secondary oxidation devices, and in disposal by dilution prevents accumulation of sludge deposits.

Chemical treatment as a process cannot compete with biochemical treatment. However, the use of certain chemicals for specific purposes, such as lime and ferric chloride for industrial waste, lime for pH control of sludge, and chlorine for disinfection and retarding odors, may not only be valuable but necessary.

The biologic processes are divided into two main classes, aerobic and anaerobic. The anaerobic treatment may be accomplished in septic tanks which may remove only 30 to 50% of the solids and produce ef-

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*Now associate-partner of Clyde C. Kennedy, consulting engineer, San Francisco.

fluents as dangerous to health as raw sewage, but nevertheless have a field of usefulness in small country homes, institutions, summer hotels, and camps; in Imhoff tanks or two-story tanks in which sludge digestion takes place in a separate compartment from that used for settling, and which when followed by trickling filters is virtually regarded by some as a standard method of treatment; and in separate sludge digestion tanks where solids are settled and removed from one tank and discharged to another for separate digestion.

The aerobic treatment plants include the activated sludge process about which there is a great divergence of opinion as to its applicability to small-sized plant installations, because of need for skilled supervision and high power consumption; the trickling filter in which the sewage moves over suitable organic films attached to the filter medium, instead of the sludge particles being circulated through the sewage as in the activated sludge process; and the intermittent sand filter which when properly operated is without rival for bacterial efficiency, but is frequently overloaded and neglected, causing a divergence of opinion as to its merits.

The cost of sewage treatment for any of the foregoing methods varies widely with cost of labor, materials, and other local conditions. A general cost data table follows (from Babbitt.)—

Type of Treatment	Plant Cost Construction per MGD capacity	Operation per MG	Operat'oner Annual	Capita Co: Construction Total
Imhoff tanks	$ 31,000	$ 4.50	$ 5.00	$0.20
Tanks and trickling filters	105,000	8.80	9.60	0.26
Activated sludge plants	74,000	11.40	10.50	0.55

Land required for treatment is indicated in the following tabulation (from Babbitt)—

Form of Treatment	Popu'ation per acre
Intermittent sand filters	1,000
Contact beds	5,000
Trickling filters	20,000
Activated sludge	150,000

Removal of Grease from Sewage. By G. A. Parkes, Assistant Sanitary Engineer, City of Los Angeles.

The literature of sewage disposal has little of value to say on grease removal. The best reference books mention sewage greases briefly, state the detrimental

effects they may have on treatment works, and agree that steps should be taken to remove oil and grease; but practically no design data or operating experiences are given. Grease or oil in appreciable quantities is detrimental to plant growth when sewage is used on land, produces 'sleek' areas around ocean outlets and greasy scum which returns to shore, clogs soil or sand beds used for disposal or treatment, and interferes with the normal decomposition of sewage sludges. The amount of grease found in the Los Angeles sewage averages 60 p.p.m. by the ether extract method; one-third is free grease and about half the free grease is unsaponifiable and probably of petroleum origin. For a city of one million people about 22 tons per day of free and combined grease is produced, and although most of it is combined and not readily available by a simple recovery process, the remaining free fat and oil leaves a problem of no small magnitude. It is likely that the amount of soap usually found in sewage would not seriously affect operation of a disposal plant. Several cities have adopted a policy of exclusion in regard to oils and greases, as easier and more satisfactory than removal. This is true in case of large industries, such as packing houses, oil refineries and restaurants, but private homes and garages produce a large portion of the oil and grease in average city sewage. Preventing the discharge of oil and grease into sewers is an enforcement problem. The cost of maintaining a force of inspectors to keep track of grease and oil traps would be disproportionate to the value received, and removal from the whole flow at some central point would be more efficient. Imhoff, in Germany, and the city of Los Angeles have carried on experimental work. Imhoff found that aeration of sewage will greatly increase the removal of grease, and this has been checked at Los Angeles where a more satisfactory aeration than 'Filtros' plates has also been devised. Experiments are also being made to determine the advantage of removal before and after screening. Grease removed may be dried and burned and may prove to be valuable for a fuel.

Sludge Digestion—By Clyde C. Kennedy, consulting engineer, San Francisco.

The purpose of sewage treatment may be defined, briefly, as the removal or oxidation of the organic content, and the reduction of the biochemical oxygen demand of the sewage effluent to meet the standard of purification required to permit its discharge and dis-

posal without nuisance or health menace. This reduction may be accomplished by screening, sedimentation, oxidation, or a combination of these processes. All methods have as their prime purpose the removal of solids, which means the production of sludge. Economic disposal of sludge is the most important problem in connection with sewage treatment. Screening removes large floating and quickly settleable solids. Burying or burning has been the most common method of disposal, but this is expensive and a potential nuisance. The city of Milwaukee has carried on experiments in a large-scale plant on tank digestion of screenings. With controlled pH and temperature at 82° F., a digestion period of 30 days was established as sufficient for rapid drying on beds. Sludge from sewage sedimentation tanks, or primary sludge whether from septic, Imhoff, or separate sludge digestion tanks, has been found by researches of Rudolfs, Baity, and others to digest best when the optimum reaction of pH 7.3 to 7.6 is maintained. Recent work also indicates that a temperature of 82° F. promotes most rapid digestion. The principle of mixing fresh sludge intimately and positively with digested sludge at a maximum rate of 1 to 20 has been established by investigators. Studies of gas production during digestion in this country indicate methane as the most important constituent, varying from 65 to 90%. Baity noted that the amount of gas produced was the same regardless of the temperature, although rates of production differed. He set the gas production for complete digestion at 420 c.c. per gram of dry organic solids. The heating value of the gas varies from 700 to 1000 b.t.u. per cu. ft. With gas collection and burning and heating of sludge, considerable savings may be made due to the reduction of digestion period from 6 to 2 months. At Klamath Falls, Oregon, this saving was $20,000 on a $70,000-contract.

The development of processes for converting secondary sludge from activated sludge into commercial fertilizer, has not proven economically feasible for small communities. Drying of sludge on open or closed beds has proven satisfactory in some instances, but the present tendency is toward digestion of mixed raw sludge and activated sludge, with an increase in the capacity of digestion tanks to 2½ or 3 cu. ft. per capita. Few experiments have been conducted in the field to determine the value of digested sludge as a fertilizer. Studies at Baltimore over a five-year period seem to show a definite fertilization of certain field crops.

The Industrial Waste Problem—By H. B. Hommon, sanitary engineer, U. S. Public Health Service.

Beginning with the World War the problem of disposing of liquid industrial wastes along the West Coast and particularly in California has become increasingly important, due to the rapid growth of industry, together with rapid growth of population and increase in use of water with consequent diminution of the supply available for dilution. The problem has confronted eastern states for several years and national and state authorities have made studies of industrial waste disposal. The problem as affecting domestic water supplies has been studied by Committee No. 6 of the American Water Works Association, which in 1922 reported 248 water supplies in 24 states affected by 20 different kinds of wastes. Treatment and disposal of wastes has been accomplished at various places by chemical precipitation, ponding in large reservoirs, recovery of wastes in industrial plants, and disposal on land. As a general rule, treatment plants which produce stable effluents are very expensive to build and operate when treating industrial wastes. The agencies exercising control of pollution by industrial wastes are: state boards of health, state commissions on fisheries, state boards of conservation, special and advisory boards, Pennsylvania Sanitary Water Board, United States Public Health Service, Department of Commerce, Department of Interior, War Department, and certain cooperative groups such as Metropolitan District Commission in Massachusetts, Sanitary District of Chicago, Passaic Valley Sewerage Commission, joint undertakings in New Jersey and in California, cooperation of nine state health departments in Ohio River basin. Organizations such as the Isaac Walton League and local fish and game clubs have also taken an active interest in stream pollution. In England, river boards have jurisdiction over entire watersheds and in Germany many districts have been organized for joint handling of sewage and industrial waste problems. (A bibliography of the more important reports, bulletins, and documents accompanies the paper).

The Control of Surges in Long Force Mains—By H. K. Palmer, chief draftsman, Los Angeles County Sanitation Districts.

In handling sewage with centrifugal pumps, the variable flow is handled by storage in a wet well and intermittent operation. In long force mains, when the

pump stops there is a long horizontal column of water in motion with nothing to overcome the inertia except friction. To prevent collapse of the pipe an air valve is placed at the summit. As the pump starts a second time some air will be expelled, but when the valve is sealed off air will be trapped and compressed, thereby applying a pressure which will cause surges near the inlet. A surge tank as near the pump as possible is usually provided to handle this surge. The computation of the size and action of the tank by the rigorous method is long and tedious, and usually unnecessary. An approximate method is to divide the cycle of operations into short intervals of ten seconds to half a minute, assume the water moving in the pipe at a given velocity and water standing in the tank at a given depth. The effect of inertia in the pipe will be to force the first water into the tank and the height at the end of a given period of time will be above the hydraulic gradient a distance corresponding to the velocity of water in the pipe, which in turn will accelerate the water in the pipe. This acceleration may be computed together with the rise in the tank with a given pump capacity. If the rise differs from the assumed rise, another approximation must be made. Where the topography of the site is such that a high open tank is out of the question, or static lift would require excessive height, it is necessary to use a pneumatic tank.

Sewage Works Operation — By Harry N. Jenks, sanitary engineer, Associate Professor of Sanitary Engineering, Iowa State College.

Sewage treatment, theory and practice, has lagged behind water purification, probably because of prior need of the latter. Preliminary handling of the sewage represents 90% of the battle in producing a satisfactory effluent. The elements may be classified as (1) design factors, and (2) operating methods. In general, design of a successful disposal plant depends on relatively few but important principles including type of plant best suited to local needs; measuring and recording devices for sewage influent and effluent, sludge, etc.; provision of duplicate units to allow flexibility in operation; by-pass arrangements with provision for emergency chlorination in case of by-passing to streams; control of water levels through the plant; means for applying chemicals at different points, and convenient methods for storing; general conveniences such as adequate water supply, office, laboratory, locker space, shower, and toilet facilities.

It is recommended that the designing engineer arrange to have the operator supplied with appropriate data relative to the physical characteristics of the plant in permanent chart and tabular form. Significant elements in operation are, the influence of sewer system factors such as excessive ground water, wide fluctuations in quantity and character of flow, and undesirable factor of long outfall lines; the city's attitude toward the plant and the operator—if the sewage works operator is a 'forgotten man' the plant will probably be forgotten; routine tests, checks, and records of operation. A sewage treatment plant, like a person in good health, runs itself with but little attention, when conditions are favorable. But when a plant becomes sick, then the operator worth while is not the one who can smile (or complain), but quite decidedly the one who can diagnose the trouble and apply the remedy. A still better operator will anticipate trouble and keep his plant in good health. The difficulty generally depends on the type of plant the operator has under his care.

Adaptability of Various Types of Sewage Disposal to California Conditions—By Chester A. Smith, Burns-McDonnell-Smith Engineering Co., of Los Angeles.

Summary and Conclusions—

First: This paper has stressed the fact that there are many factors entering into a general sewage disposal problem. One factor may be the major item in one individual problem, and the rest more or less minor factors, while in another case some of the other factors may be of first importance.

Second: That California has probably the widest range of conditions affecting sewage disposal of any other state. It has the greatest range in land elevations, the greatest range in development of land areas and density of population, and the greatest range in availability of water for dilution or receiving sewage effluents. It has a wide range in climatic conditions and geological formations. The necessity for water development, the protection from pollution and conservation for the future development of the state, are outstanding problems. The coming of new industries together with the present natural industrial plants of the state, adds more complications to proper sewage treatment and disposal.

Third: That the state is divided into three general zones by the relative importance of the factors influencing sewage treatment and disposal. These zones are: the mountainous zones, which are classed as our

water-supply areas; the valley zones, where agricultural developments depend upon water conservation; and the coastal zone, with the great population densities, requirement for water for industrial and residential expansion, and the availability for disposal by dilution in the ocean.

Fourth: That with such a range in conditions, from desert to densely populated areas, the degree and type of treatment adaptable may vary from the primeval method as demanded in the first sanitary regulations set forth by Moses, to a treatment plant that will produce an effluent comparable in quality and purity to natural ground waters.

Fifth: That for small mountain seasonal resorts, taverns, and scattered cabin communities, the chemical toilet offers in most cases the most satisfactory method of sewage disposal. For the larger, more permanent resorts and towns, a complete oxidation process with chlorination of effluent is required, where the effluent is discharged into a stream. The type of plant should be sedimentation followed by either trickling filters or aeration, depending upon local conditions.

Sixth: Land treatment. There are a few cases, where raw sewage may be spread upon land where public health may not be seriously endangered and where there is sufficient isolation to prohibit complaints from odors. There are now 15 cities and communities in this state using this method, but by no means are all operating satisfactorily.

In the majority of cases pretreatment by sedimentation is necessary, and then sufficient isolation and ample areas for irrigation on land absorption without pooling or water-logging the land, are prerequisites.

Seventh: Two-story tanks of the Imhoff type or settling tanks with separate tanks for separate sludge digestion, are the best adapted for preliminary treatment.

For small installations, where on account of lack of funds for proper daily inspections and operation, the two-story tank will probably be the better, as it will continue to function fairly efficiently, with less attention. For larger installations, the separate sludge digestion type has many advantages over other forms of sedimentation tanks.

Eighth: The trickling filter and activated sludge method are the two types of final treatment most adaptable in the majority of cases in California.

Available gravity heads, local costs of material (particularly filter stone), power costs, first construction

and operation costs, isolation, odor control costs, and available areas for treatment plant sites and character of effluent required, are all determining factors in the selection of the method.

Trickling filters require 15 to 20-ft. operating heads, greater land areas for construction and isolation, greater first costs than the activated sludge process. Trickling filters probably will stand more abuse from lack of proper attention and operation with fairly efficient results, and the operating costs are lower than the activated sludge method. However, if pumping is necessary to operate the filters, chlorine is required for odor control, and with the overhead on greater construction costs, the operating costs may equal or be greater than the operation costs of activated sludge.

Both methods will produce stable effluents. As the filter must be unloaded at certain periods of the year, the effluent from a sprinkling filter will be turbid or cloudy.

As a general statement, trickling filters are adapted for the smaller cities where topographical conditions are favorable, proper isolation obtainable, operation and maintenance probably doubtful from lack of finances or ordinary neglect, and the effluent not required to be clear, as necessary for discharge into an irrigation canal having a clear ground water for supply.

Activated sludge is adaptable where only small areas are available for treatment plants, and isolation practically impossible, as in the more thickly populated areas. The low power costs in most areas in California have reduced operating costs, and the later developments in design have made a further reduction.

Intermittent sand filters will also produce stable clear effluents, but are usually not economical on areas for same available in California.

Ninth: Sterilization and odor control. Liquid chlorine gas is the most efficient and economical as a germicide. It is not dependably positive for raw sewage and the amount of dosage necessary for raw sewage usually makes a pretreatment process before the application of chlorine, more economical. The most satisfactory and economical results are with stable effluents.

Recent experiments and installations with the use of chlorine for odor control in California as well as in other States, have been very satisfactory. It has been particularly adopted for odor control and retardation of putrefactive agencies in the disposal of milk wastes in several California locations.

Chlorine has been used in a number of instances as an emergency measure to reduce the odors of an overloaded or outgrown plant, lack of intelligent or improper operation, antiquated types of treatment plants, reduced isolation, and various other causes. Sometimes the odor troubles are the convincing arguments necessary to induce a community that the existing method of disposal is really dangerous and unsatisfactory, and that a better method of treatment and disposal is necessary.

It is Smith's belief that there are a number of cases where, with the selection of a better type of treatment and with a design of a type for minimizing odors by covering of exposed sewage areas, gas collection and burning, and similar devices, better general results may be expected and odors controlled more economically than by the use of chlorine gas.

Tenth: That in California, the limited supply of fresh water for future growth and development will bring forth the necessity for conservation of sewage wastes by the use of high-grade treatment methods for use in preparing sewage wastes for irrigation, certain industrial purposes, or for ground water replenishment.

For the coastal zone, where the ocean may be the most economical and only feasible place of disposal, better and more efficient methods of pretreatment will be required to protect the bays, harbors, and beaches from sewage pollution, and the residential property and recreational areas from depreciation of property in the vicinity of the outlet.

Efficiency of Sewage Screens—By W. T. Knowlton, sanitary engineer, city of Los Angeles.

A recent estimate shows that there are about 75 fine screens in operation, or those with the smaller dimension less than ⅛-in. These remove about 25% as much suspended matter as that collected in sedimentation. The more common types are Riensch-Wurl, Dorrco, and Tark or Link-Belt. A survey by the author nine years ago showed percentage removal by Riensch-Wurl screens varying from 5 to 16%. At the Hyperion plant, Dorrco screens in December, 1926, indicated 10% removal, but in November, 1927, and again in March, 1929, over a 48-hr. test period less than 4%. Tests were made by collecting weighted composite samples of screened sewage every half-hour for 2-hr. periods, and of screenings every half-hour for 6-hr. periods. A total of about 1 cu. ft. of screen-

ings was collected, measured, and weighed. The suspended solids in screened sewage were determined by the Gooch crucible method, and moisture in screenings was determined on a sample of at least 500 gr.

Bacteria in Sanitary Engineering—By A. P. Banta, assistant engineer, Los Angeles County Sanitation Districts.

Bacteria are the simplest form of plant life. They are grouped according to shape as bacilli (rod shaped), cocci (globular), or spirilla (cork screw). There are about three times as many bacilli as cocci, and five times as many cocci as spirilla. They are also grouped as pathogenic or non-pathogenic, according to their ability to cause disease in man and animals. The sanitary engineer is concerned primarily with the effect of environment on the bacteria and that of bacteria on their environment. All bacteria may be grouped in one of three classes, (1) obligate aerobes, or those requiring free oxygen; (2) obligate anaerobes, or those requiring absence of free oxygen; (3) facultative anaerobes, or those indifferent to presence of free oxygen. Anaerobes obtain energy by splitting up compounds used for food, working best at temperatures of about 77° Fahrenheit and pH 6.8 to 8.0. Aerobes obtain energy by direct oxidation of organic compounds, probably at optimum temperature of 72° Fahrenheit or lower, and pH 7.4. Under unfavorable environment certain bacteria shift vital portions of the cell into a resistant dense spherical or elliptical membrane called a spore. Fortunately few pathogenic organisms form spores. Bacteria reproduce by division of cell into two parts. Under favorable conditions the ratio of increase is enormous. It has been estimated that if conditions remained favorable descendants of a single cell in five days would produce a mass which would spread a mile deep over the oceans. All results produced by bacteria are products and byproducts of their food assimilation products, including secretions, excretions, and disintegration products. Secretions are agents rendering food available to bacteria, excretions are substances rejected as useless, and disintegration products are the residue and unused portions of food materials. Enzymes are the most important secretions. They are called catalysts, being capable of producing chemical change while not entering into the reaction. A small amount of enzyme is capable of causing a large amount of chemical changes, rendering food materials soluble, and in a form capable of

assimilation by all the organisms. Enzymes are divided into five groups, oxidizing, reducing, protein splitting, fat splitting, and carbohydrate splitting. A single bacteria does not embrace all reactions possible in a classification, for example one may produce nitrate from ammonia, but not nitrate from nitrite. Most bacteria produce enzymes which attack several different types of foods, and the end products of activity of one group of the bacteria may furnish food for another. Putrefaction and fermentation may go on at the same time in decomposition of organic matter and the two words are often wrongly used interchangeably. Some enzymes are reversible, for instance the fat splitting enzyme lipase under proper circumstances is able to produce fat from glycerine and fatty acids. In the normal operation of sewage collection and disposal works there are many manifestations of bacterial action, some readily recognizable, others more subtle.

In long outfall sewers on flat grades, the sewage coming into the sewer has its dissolved oxygen depleted to a point where anaerobic bacteria function, the sewage becomes septic, and sulphur bearing proteins and mineral sulphates are attacked with the formation of hydrogen sulphide, which gives off the 'bad egg' odor, and iron sulphide which gives the characteristic black appearance to the sewage. Hydrogen sulphide is dissolved in moisture above the water line, oxidized by bacteria and by direct oxidation into sulphuric acid which attacks concrete. It has been found possible to inhibit the formation of hydrogen sulphide by introducing chlorine into the collecting system above points of hydrogen sulphide production, and thus control odors. In sludge digestion anaerobic bacteria liquify approximately 30% of the sludge by body metabolism or enzymic action. Presence of excessive quantities of enzymes or excretions inhibit or stop bacterial activity and it is readily understandable that stirring or circulating sludge to reduce their concentration is an advantage. Sewage disposal by dilution in portions exceeding 1 to 5% may produce deoxygenation of the receiving body of water. Although experiments indicate high mortality of pathogenic organisms in disposal by dilution, some typhoid bacilli have been found a week after discharge and chlorine is frequently used to protect against water borne infections from this cause. Bacteria probably play an important role in the activated sludge process, but there is no agreement as to whether the process is essentially physical or biological.

Use of Chlorine in Sewage Treatment—By R. F. Goudey, resident engineer, Los Angeles, California State Department of Public Health.

During the past two years, under the leadership of the Chlorine Institute, Inc., great strides have been made in application of chlorine to sewage treatment. Reduction of cost in ten years from $0.20 to $0.045 per pound has helped to popularize chlorination. Sewage chlorination includes disinfection, control of odors at treatment plants, combatting various operating difficulties (such as overcoming of filter ponding, nuisance from filter flies, and controlling of Imhoff tank foaming), making of coagulants for sludge conditioning prior to filtration, and in the partial oxidation of unstable sewage effluents. Chlorination is the most reliable and practical method of sewage disinfection known, but requires consideration of many important factors. The most important chemical reactions involved are the almost instantaneous reaction with gases in solution, the slower absorption of chlorine by organic substances in suspended, colloidal, or soluble forms, and a disinfecting action by chlorine entering the protein of the protoplasm of microscopic organisms.

The 'chlorine demand' is the amount necessary to cause a residual at the end of the period considered. For a 15-minute period it is the approximate amount required for disinfection. Theoretically 2 p.p.m. of chlorine will neutralize 1 p.p.m. of hydrogen sulphide, but actually about 2.5 p.p.m. are necessary. Requirements for good chlorination are; first, a contact period of 10 to 15 minutes; second, minimum hydrogen sulphide; and third, minimum oxygen demand; but usually not all these can be met and they must be valuated. Linn H. Enslow, research engineer, Chlorine Institute, Inc., gives the following useful table for the amounts of chlorine needed for disinfection:

Nature of Sewage	Chlorine p.p.m.
Crude sewage or settled sewage (fresh to stale)	5 to 15
Crude sewage or settled sewage (septic)	10 to 25
Sprinkling filter effluent	2 to 5
Activated sludge effluent	1 to 3.5

The first reported instance of odor control at treatment plants is reported by Elms and Waring in 1912 at a septic tank in a suburb of Cincinnati, Ohio, where calcium hypochlorite was used. The first successful installation in California was made at Newport Beach during the past year to control odors from an Imhoff

tank. Chlorine at 4 to 10 p.p.m. is added to the incoming sewage. An Imhoff tank-sprinkling filter installation with chlorination at San Bernardino was put in operation February, 1929, at a location where without chlorination it would probably have been a nuisance. Hydrogen sulphide is the most important gas to be controlled at sewage disposal plants. It is formed in moderate amounts in all sewages after they are five hours old, and if the water supply contains mineral sulphates enormous quantities are formed. Hydrogen sulphide released to the air tends to dissipate slowly and becomes a disagreeable odor nuisance up to 1 part per billion travelling ½ to 3 miles. The spread is more pronounced in warm weather, at night and when air movements are sluggish. Ferric chloride produced at treatment works from ferrous sulphate and chlorine gas gives a coagulant for conditioning activated sludge, as yet superior to any other. Prechlorination at Pasadena caused activated sludge to bulk, and this phenomenon should receive further study. In live streams used for fish culture, the chlorine allowed to escape to the stream should be carefully controlled. Immediate mixing of sewage with chlorine should be provided. Solution feed chlorinators have proven more satisfactory than dry feed. Where positive results are necessary, triplicate installations with two operating at split feed should be provided. For odor control duplicate installations are not necessary. Orthotolidin test for residual chlorine should be made often enough to insure consistent chlorination.

The Sewage Situation in California. By C. G. Gillespie, Chief, Bureau of Sanitary Engineering, California State Department of Public Health.

The net increase of cities and towns was from 260 to 268 for the years 1922 to 1928, and the net increase in governmental units and institutions 20, yet there have been at least 56 communities that have installed whole systems of public sewerage in that time, 45 having sewage treatment and nearly half of these high grade producing a stable, oxidized effluent. The percentage incidence of public sewers in the state was in 1913—62.5%; in 1923—76.5%; in 1928—85.5%. If the curve means anything, universal sewerage will arrive in California in another generation. (Note: This paper is only briefly abstracted as it was published in full in the July, 1929, issue of the 'Sewage Works Journal' of the National Federation.)

How to Write an Article for a Technical Periodical

By Philip Schuyler*

It is a sad commentary, but nevertheless true, that the two shortcomings of the average engineer of today are: his inability to express himself clearly, concisely, and therefore convincingly, in speech and in writing; and, his lack of salesmanship. And yet, without these assets, all the technical training and experience may be of little avail if he cannot sell his services.

This inferiority complex is the result of a steadily increasing curriculum of technical subjects in our colleges, during the past thirty years especially, which has crowded out English, economics, philosophy, and languages, subjects which the engineer of earlier days included in his education. The result is that we have over-specialized engineers—diligent, practical, serious, and technically efficient, it is true—but otherwise uncultured, and thus handicapped in the economic struggle of today. I believe the pendulum already has begun to swing back, and we may soon have engineer graduates with a better balanced education.

If we are going to achieve success—and, as a corollary, secure greater remuneration—we must be able to 'sell ourselves'. Therefore, we should aim to develop a winning personality, and at the same time be convincing; which means that we must be able to write and speak clearly and concisely.

An engineer's reports and his published articles are frequently the chief criteria for judging his ability and personality. An engineer's promotion, or employment on some big project, many times depends on how these reports or articles are written. A terse, concise, and convincing report will open the door to wider opportunity. The same thing is true of an article published in a technical periodical, it will make friends—even clients—of those who read it.

T. A. Rickard, mining engineer, and for many years editor of 'Mining and Scientific Press', and now re-

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**Paper read at School of Citizenship and Public Administration, Short Course, University of Southern California, Los Angeles, June, 1929.

tired, is probably our most meticulous engineer in the use of technical English. His book 'Technical Writing', first published in 1908 and later revised, is a text book used in many universities. The profession owes him much for inciting more interest in writing clear, concise, and correctly composed articles. Among other things he states:

"There should be no need to lay stress upon the part that writing plays in an engineer's life. . . . But the engineer bungles language deplorably. He makes a fetish of efficiency, yet he shows no regard for the effective use of one of his most important tools—the pen; he believes devoutly in accuracy, yet he employs an instrument of precision as carelessly as a small boy handles a gun."

I am supposed to tell you how to write or prepare an article for a technical periodical.

My idea of a well-written article is one that can be read rapidly, without having to pause or re-read a single clause or sentence; the reader retaining a clear, concise picture of the subject discussed. Some call the ability to write a gift, but I believe it is rather the combination of practice and clear thinking resulting from a thorough knowledge of the subject.

Of course, a highly technical article, especially one containing long formulae, will take longer to read and will be harder to assimilate. But, even this type of article, by careful planning and clear phraseology, can be made readable and quickly understandable by one familiar with the subject.

Consider your subject well before you begin to write; dwell on it; marshal the salient facts in your mind; for clear writing is the consequence of clear thinking. You will find it best first to prepare an outline of the subject. Arrange this skeleton outline into main headings and subheadings; being sure it is in consecutive stages. If you have not marshalled all the facts clearly in your mind, jot down notes, or write a few sentences under each heading as they occur to you, before attempting to write the article. Begin the article with a brief general statement of the subject to be discussed or described.

As technical writing is principally description and exposition of facts, good arrangement is essential. Remember that short sentences are easier to understand than long ones. Long sentences, full of unsorted and unrelated ideas, are confusing and tiring to the mind of the reader. Variation in the length of sen-

tences is preferable, and makes more agreeable reading.

Choose 'fitting' words—words that properly belong to the subject described. When in doubt refer to the dictionary for the correct definition. For instance, engineers frequently fail to draw a distinction between such words as **accuracy** and **precision**; **mistake** and **error**; **balance** and **remainder**; **further** and **farther**; **equable** and **equitable**; **contemplating** and **considering**; **partly** and **partially.**

As Rickard points out "The engineer tries to be exact in all his measurements; he should measure his language with similar exactness." And as Flaubert said "The chief aim in style ought to be absolute precision; there is only one noun that can express your idea, only one verb that can set that idea in motion, and only one adjective that is the proper epithet for that noun."

Walter D. Binger, in his recent book 'What Engineers Do', states "It will be helpful to try to create a distinction between the meaning of the words **accuracy** and **precision,** as well as **mistake and error.** In engineering the word **accuracy** usually refers to results, while **precision** refers to instruments and methods. **Mistake** is used to describe human efforts, while **error** also refers to instruments and methods."

Let me give you a few illustrations from articles submitted to me for publication in Western Construction News:

'Only five cubic yards of the concrete was used; the **balance** was thrown away'. Obviously this should be 'the **remainder** was thrown away'.

'It was inconvenient at that time to continue **further** north'. **Farther** is the correct word in this case, whereas **further** should have been used in the following: 'the **farther** he went with his investigations'.

'The **equitable** climate of California makes life worth living.'

'The engineer made an **equable** division of the cost of operation.'

Transpose **equitable** and **equable** and these sentences would be correct.

'Maintenance of the sprinkling filter requires only the **partial** time of one man.'

Since **partial** means biased or prejudiced, we should use **part of the.**

'Under the microscope **partially** formed crystals are visible.' This engineer obviously meant '**partly** formed crystals are visible'.

Avoid the use of superlatives and adverbs, such as **very, tremendously, enormous, rather, somewhat, perfectly, extremely, exceedingly, considerable.** For instance:

'The survey required only a **very limited number** of stakes.' As this engineer apparently did not know the exact number and therefore could not be precise, he should at least have tried to be concise and used **few** instead of **very limited number.**

'This investigation proved to be an **enormous undertaking.**' He might just as well have gone a step further and said 'a **rather exceedingly enormous** undertaking'. **Big** is a small word, but big enough in this instance.

'The sewer was laid on a **perfectly** straight line and **extremely** flat grade.' Since a straight line cannot be anything else but straight, **perfectly** is superfluous; and I will leave it to you to determine what is an **extremely flat grade.**

Another engineer described the canyon walls as being **'very vertical'.**

This brings me to the abundant use of **approximately** and **about.** Apparently the majority of engineers love these two words, and without them they would be at a loss to describe anything. I received one article from a prominent engineer describing in detail the design and construction of a dam, in which he used **approximately** and **about** forty times on one page. He gave the dimensions of the dam as **'approximately** 337.73 ft. **in height** and about 1200 ft. 4½ in. **in length.** As he gave the exact height it could not be approximate; his second measurement should have been expressed in decimals to correspond with the first, and, **about** omitted; and he should have used **high** and **long** instead of **in height and in length;** as the word **in** follows **in.,** the abbreviation for inches. In another place he stated that 'the excavation was carried down **approximately about** to bedrock'. This article also was 'sprinkled' with such words as **probably, perhaps, more or less completely, to a greater or less extent, very roughly about.** Evidently this engineer did not wish to commit himself on any point. When an article like this is read aloud it sounds ridiculous, to say the least.

When figures are expressed in round numbers, whether written in words or figures, such as four (f-o-u-r) or 1200 (one-two-double zero), they are approximate. When expressed in fractions they are exact. In either case **about** or **approximattely** is superfluous.

Data, strata, media, and **phenomena** are plural nouns, and yet so many engineers, many of them prominent, write about 'the data **is** obtained', instead of 'the data **are** obtained'; **'much** data are required', instead of **many** data are required', the engineer in this case using both singular and plural; 'there were **less** strata than anticipated', instead of '**fewer** strata'; 'this **phenomena** was frequently observed', instead of this **phenomenon** or these **phenomena.**

Due to and **due to the fact** that are frequently misused. It were better to use **as a result of,** or **in consequence of,** or merely **because.** Nevertheless **due to** should be used sometimes in preference to **owing to** as in the sentence 'the damage was **due to** a landslide'.

Tends to is another misused term, as in the following: 'the use of Celite **tends to aid** in making the mixture more workable'; which can be better expressed 'the use of Celite **aids** in making the mixture more workable', or better still, 'the use of Celite increases the workability'.

Also, **'it is the belief of many'** can be simplified to **'many believe'.**

Another example of poor English frequently heard is 'we are going to try **and** secure better results' and 'try **and** do it', instead of 'try **to'.**

'Locate' is another pet word used profusely, and most of the time incorrectly, by engineers. The definition of **'to locate'** is 'to place; establish; mark out and determine the position of; to settle'. A **mining claim** is **located,** and surveys of railroads, land, etc., are **location** surveys. Nevertheless, the geologist says 'I **located** several strata of gypsum in the bed of the ravine', and the engineer states that 'the Cle Elum river is **located** in Washington'; 'the point of discharge of the effluent is **located** on land nearby'; 'the concrete mixing plant was **located** on the hillside above the dam'; the chief engineer is now **located** in Pasadena'; 'the superintendent's house is **located** on Second avenue'. Correctly speaking, 'the geologist **found** or **discovered** several strata'; 'the Cle Elum river is in Washington', omitting **located;** 'the concrete mixing plant was **built,** or **constructed** on the hillside'; 'the point of discharge of the effluent is on land nearby'; 'the chief engineer is now **residing** in Pasadena'; and 'the superintendent's house is **situated** on Second avenue'.

Engineers also **'contemplate'** and **'execute'** too much, as for example 'the management **contemplates** the installation of another unit'. The engineer probably

means 'the management **plans**, or **proposes**, the installation of another unit'. Also, 'the entire job was well **executed**'. He means well **done** not well killed. Another engineer wrote that 'the project was **prosecuted** expeditiously'.

It is easy for an engineer on construction and in frequent contact with laborers, to become slovenly in speech, which is reflected in his writing. Bad writing is nothing more than carelessness, ignorance, or insincerity. Try to be concise, lucid, and logical. Stevenson said: "If a man can group his ideas, he is a good writer."

I find that the best articles are those written in longhand; corrected, typed, and then edited. Read the manuscript aloud to yourself, and you will find many more things to correct than when you read it silently. Then read it aloud to your wife, younger brother, or son. They may not understand the subject detail, but they will help you in other ways. Use as much pains and effort in writing the description of your project, as you have put into the details of design and construction.

An article written in the first person singular is preferable to one written behind **we** or **the writer** or **the author.** When an engineer writes an article he is virtually testifying as a scientific witness, and vouches for the accuracy of the statements therein. There is nothing indecent or egotistical in the use of the first person singular, unless it is needlessly repeated; rather it strengthens the statement. Mark Twain said "the only people entitled to use the first person plural are kings, editors, and persons afflicted with a tapeworm".

I am glad to note that P. B. McDonald, associate professor of English, college of civil engineering, New York University, has had the temerity to take issue with the secretary of the American Society of Civil Engineers on the society's customary instruction to contributors to the 'Proceedings' and 'Transactions', which reads as follows: "This discussion should be written in the third person, complying with the general form which has been in use in our publications for some years." In his article on 'The Young Engineer and Engineering Style of Written Expression', in the September, 1928, issue of 'Engineering and Contracting,' McDonald comments as follows:

"The essence and aim of a discussion following an original paper is that the members shall give their individual opinions of the facts or theories advanced in the paper. In arguing orally about such facts or

theories the member would naturally tend to use such expressions as 'In my opinion', 'I would suggest', 'To me the statement seems exaggerated', 'My own experience in conducting research', 'I would criticize just one point'. Such expressions bring out exactly the personal element that makes discussion and criticism interesting and worth while. Yet the members are forced by an old form to couch their comments in such unnatural and roundabout jargon as 'It is suggested that', 'Reference is here made to ', 'The speaker wishes to propose', 'The experiments were conducted under the supervision of the writer'. Could anything be more dry-as-dust than such phraseology?" And McDonald concludes by asking: "Is it not time to relegate the third-person style for engineers' reports to the historical background of obsolescence where the engineer has put so many tools of his advancing profession?"

Most engineers who send articles to us for publication specifically state 'please edit, correct, or rewrite as you see fit'. Nevertheless, there are a few who object to having their articles edited, as they are afraid that their 'style' will be ruined. As a matter of fact there is little room for style in technical writing. What some of these engineers mistake for style is a bad case of 'slovenitis'. There are a few engineers who have written many articles for publication; who are exceedingly careful in their preparation; and have a right to object to much editing without their consent.

When your article has been published by a technical periodical of standing, compare it carefully with your original manuscript; in this way you will learn quickly.

It is not my intention to discourage you, but rather to incite in you greater effort in the preparation of articles. An engineer has at his command a small and simple tool—the pen—a tool, nevertheless, mightier than the slide rule or logarithmic tables; a tool that will bring him greater returns, if properly used, than any other. Bear in mind that an engineer needs more publicity, and cultivate the habit of writing.

Editorial Style—Technical periodicals endeavor to be consistent in the use of capitals, abbreviations, and many other details. This is termed 'editorial style'. Newspapers do likewise. I will give you a few of the most important.

Capital Letters—The use of capital letters should be avoided wherever possible. This is probably the

most difficult problem which the editor of an engineering periodical has to decide. The newspapers are each year using fewer capital letters for titles, names of committees, such as 'consulting engineer', 'governor of Nevada', 'board of consulting engineers', 'Bayshore boulevard', 'state of California', 'Mokelumne river'.

I am following in the footsteps of the newspapers and trying to reserve the use of capitals for proper names only.

Mister—When you first refer to a man, use his initials, without the prefix 'Mister', as 'A. B. Smith'; or, spell out his first name if he has no middle initial, as 'Paul Jones', which is preferable to 'P. Jones'. When you refer to him again, then Mr. Smith or Mr. Jones is proper, although I prefer merely 'Smith' or 'Jones'; which I note is the style to which the daily press is now resorting.

If a man is dead he should never be given the prefix 'Mister', although the American Society of Civil Engineers still insists on doing so. You do not say 'Mr. Shakespeare', 'Mr. Washington', or 'Mr. Lincoln', so why 'Mister' the less known dead?

Punctuation should be most carefully used by an engineer, as its misuse may easily change the meaning of a sentence. I believe commas should be used at the end of each natural pause in speech. As an example of how wrong punctuation may change the meaning of a sentence, note what happens in the following: 'The chairman of the board says the engineer is a fool'. By placing a comma after 'board' and another after 'engineer', the chairman becomes the fool instead of the engineer.

The following sentence without punctuation is ambiguous; and is also a good example of putting the cart before the horse. 'After the laying gang followed the jointing and cradling gang'. Without a comma after the first 'gang', it might be inferred 'after the laying gang had followed the jointing and cradling gang'. The sentence, of course, should be written: 'The jointing and cradling gang followed the laying gang'.

Word Repetition—Avoid the use of the same word twice in a sentence. Also, the use of the same sounding word with a different meaning.

Abbreviations—If only a few quantities are given in an article, it is usually preferable to spell out such words as feet, cubic yards, pounds, horse-power; but if many quantities are given, abbreviations simplify

reading and are proper. The following are a few standard abbreviations:

linear or lineal	..... lin.
feet	..... ft. not fts.
inches	..... in. not ins.

because abbreviations should never take plural.

degrees of angle.....60 degrees, or 30½ degrees, except when minutes and seconds are added, as 24°19′, or 18°12′42″.

These abbreviations should be reserved for degrees of angle and not used for feet and inches.

degrees of temperature	..... 60°F. or 30°C.
pounds	..... lb. not lbs.
gallons	..... gal. not gals.
hours	..... hr. not hrs.
cubic yards	..... cu. yd. not yds.
acre feet	..... ac-ft.
kilowatt hours	..... kw-hr.
square inches	..... sq. in. not ins.
barrels	..... bbl. not bbls.
horsepower	..... hp.
miles	..... mi.*
square miles	..... sq. mi.*
acres	..... No abbreviation.

(*only when used many times)

Hyphenated Words—The following are some of the most frequently used:

One-half, one-third, one-quarter.
Re-locate, re-incorporate.
Cut-off.
Through-route.
Pressure-filter.
Pipe-sections.
Air-hammer.

When two words are used as an adjective, hyphenate them, as for instance:

Main-line track.
Dry-mix cement mortar.
Centrifugally-spun pipe.

Consistency is frequently used incorrectly instead of **consistence. Consistence** is the degree of firmness or density, such as, of mud, or dough, or concrete; **consistency** is compatibility or harmony between things, acts, or statements.

Numerals in four figures should be written without comma such as 5000, not 5,000; but the comma should be used when five or more figures are used, to separate hundreds as in 50,000 and 5,000,000. Deci-

mals should always have the cipher before the decimal, because the type of the period is so thin that it is easily broken off, or the typesetter may leave it out.

Use white paper in preference to yellow, pink, or green; as colored papers are hard on the eyes of editor, proof-reader, and typesetter. Use opaque and not transparent or tissue paper for the same reason.

Avoid hyphens at end of lines; rather start word on following line.

Have your article typed double or triple space—not single space—to allow room between lines for corrections.

Send original and not carbon copy to the editor.

Antimony Method for Sulphide Determination

Using Antimony Potassium Tartrate to Precipitate Yellow Antimony Sulphide in Acid Solution

By A. J. Salle and E. A. Reinke *

Reagents—

1. Antimony potassium tartrate solution, 50 gm. per liter.
2. Hydrochloric acid (1:1).
3. Standard potassium dichromate solution, 2.50 gm. per liter.
4. Standard cobaltous chloride solution, 24-gm. crystals in distilled water, add 100 c.c. concentrated HCl, and dilute to 1 liter. (Same as 'Standard Methods' for iron.)
5. Standard silica suspension, 100 p.p.m.
6. NaCl crystals.

Preparation of Standards—

Add 1.05 c.c. potassium dichromate solution. 2.4 c.c. cobaltous chloride, and 10 c.c. silica suspension, for each 1 p.p.m.S. Make up to 100 c.c., in 4 ounce clear glass bottles. Prepare standards of 0.5, 1.0, 2.0, 3.0, 4.0, and 5.0 p.p.m.S.

Procedure for Total Sulphide—

Add 1 c.c. antimony solution and a few crystals of NaCl (about 0.5 gm.) to sample bottle, and fill to 100 c.c. with water or sewage to be tested. Yellow color indicates presence of H_2S. After mixing add 1 c.c. HCl solution. Compare with standards. In sewage work, a blank sample should be placed behind the standard to effect equal turbidities. The reading fixes total sulphides (soluble in dilute HCl).

Procedure for Volatile Sulphide—

Thoroughly aerate a portion of the sample by shaking for at least one minute, or until no odor of H_2S is observed. Repeat procedure for total sulphide. If all the HS has been removed, no color should be noted until the acid is added. The reading is fixed sulphide. The difference in readings is volatile sulphide.

*Bureau of Sanitary Engineering, California State Department of Public Health, Berkeley.

Note—Acid should not be added until antimony solution has been mixed with sample, as otherwise a precipitate of antimonic acid will be formed.

If sample contains more than 5 p.p.m.S, the quantity may be determined by dilution after the addition of reagents with S free water.

Supplementary Statement—

This method has been developed in the laboratory, and tried out in the field on some 500 determinations, both water and sewage, and has proven satisfactory. We think the principle involved, that of forming a metallic precipitate which is not interfered with by organic compounds in water or sewage, is a marked improvement over the present A. P. H. A. method which we have found entirely unreliable in sewage work.

Recent Development in Sewage Disposal in the East

By R. F. Goudey*

The following statements are based on observations made at sewage treatment plants of Chicago, Aurora, Milwaukee, Cleveland, Boston, Brockton, New York, Plainfield, Baltimore, Salem, Ohio, and Indianapolis, as inspected by me during August and September. 1929.

Bar Screens

All of the new plants are being equipped with self-cleaning, one-inch bar screens, of which there are now four new types. The simplest of these is the Evers, Sauvage Co. screen at Calumet. It is a small, compact, and satisfactory screen, and operates continuously.

The second is a type developed by a man named Johnson, of the Chicago Sanitary District, for the North Side plant, and is made by the Link Belt Co. Owing to the steepness of bars and the clumsiness of the raking device, most of the material is lost before reaching the top. Further changes should be made upon it before it is used extensively.

The third type of screen is the Dorr type, perfecting the design originated by the city of Los Angeles at Hyperion, such as installed at Aurora, Illinois. A number of the operators and engineers who were interviewed, disliked the curved bars of this screen, which occasionally get out of alignment, causing trouble. This has led to a new type of Dorr bar screen, first installed at Salem, Ohio. The unique features are the carrying of the water on the same carriage which operates the rake, and the use of straight bars. It operates automatically only when the loss of head exceeds four inches. It appears to be an excellent screen.

In addition to the general installation of mechanically cleaned bar screens, there has been a move to make them operate intermittently and automatically. At Aurora, Illinois, and Salem, Ohio, the screens operate when the loss of head through the bar screen

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reaches 4 in. A contact is made which operates the bar screen until the loss of head is reduced to normal. The saving in the wear on the machine alone justifies automatic operation. In addition, greater removals are secured, because, with fuller loads on the rakes, fewer solids are lost.

At the North Side plant, Chicago, the screens are operated automatically, but according to a predetermined and fixed cycle of operation.

Incineration of screenings is now being practiced at Salem, Ohio, in a little apartment-house incinerator set adjacent to the screen and in the same house with the screen. This incinerator is manufactured by the Buffalo Cooperative Stove Co. The main feature is that the burner operated by gas from the digestion tank has ports on the underneath side and serves as a grate for the screenings which are thrown directly on top of the burners.

Pressing of screenings at Milwaukee by the Berrigan Press to 6% moisture has proven troublesome in cleaning. A centrifuge is now being installed.

Grit Chambers

Owing to the fact that practically all of the grit chambers, as used in the east, are settling out organic matter, which causes odors in the material removed from the grit chambers, there has been a movement to design mechanically operated grit chambers for new installations, and to install mechanical washing devices for old installations. Aurora, Illinois, has a new type of Dorr detriter. This is merely a shallow tank with 18-in. water depth, giving a detention of 40 sec., and has on the bottom a revolving system of rakes, forcing the grit to a hopper in one side of the tank. Here it is picked up by the tractor belt, which gradually works the grit up a narrow slot to a point of discharge above the water level. The gradual rubbing of the sand in this channel washes it free of organic matter, and this organic wash water has a separate channel back to the detriter tank. The success of this type of detriter is very marked.

At Salem, Ohio, the grit chamber has been designed in conjunction with a grease removal plant, prior to preliminary clarification. Air is made to keep the organic matter in suspension. The installation is successful.

Promising experiments with a Dorr type of grit washer are now being conducted in the open grit chambers at Milwaukee.

Many of the eastern plants have housed over their grit chambers.

Fine Screens and Screenings

The use of fine screens in sewage treatment is on the decline. None of the new plants visited or that I heard talked of, used, or expect to use, fine screens in any part of the process.

A rather unique use of fine screens is in connection with sedimentation at Indianapolis. The sewage flows through a channel and battery of fine screens, and approximately two-thirds of the sewage water is screened. The solids remain in the one-third sewage flow not screened, and this concentrated flow is then allowed to settle. This unquestionably is a step in the right direction, as it gives a more concentrated flow to settle, and more efficient methods of settling can be devised for it. At the present time, the efficiency of the settling tanks at Indianapolis has not been worked out to where they get an overall removal greater than 36%. This may be due to faulty removal of deposited material.

Baltimore passes the settled effluent through a 20-mesh screen to remove floating solids and grease prior to dosing or sprinkling filters.

Milwaukee has demonstrated the success in digestion of screenings. The entire output of screenings from their plant is pumped to heated digestion tanks with gas collection. Heat is generated entirely from gas collected. A production of 120 cu. ft. of gas per million gallons of sewage flow is being obtained with a temperature of 130°. Good digestion is obtained in less than 30 days, and lower temperatures down to 80° D. are being used. The digested screenings are odorless and dewater readily. The plan is to return the digested sludge to the incoming sewage. What effect this will have on the treatment plant has not yet been determined.

The Tark screens at Milwaukee have been giving excellent results; the brushes not giving any particular trouble from wearing, as was anticipated by many engineers.

Preliminary Sedimentation

Imhoff Tanks—The outstanding feature of sedimentation is that no new two-story tanks are being built. At Plainfield, New Jersey, the Imhoff tanks are being reconstructed to give plain sedimentation. The flowing-through chambers are removed and steep sides are given to the hopper bottoms. The modified

two-story tanks give far better removals, 60% and better, and effect a very material saving in labor. Instead of having a man spend his full time removing scum from the flowing-through chamber and breaking up scum in the gas vents, the scum formation with the plain sedimentation tank is practically negligible.

Baltimore has given up the use of two-story tanks and has a large number lying idle.

At Calumet, scum was being removed from the two-story tanks for the first time in seven years. It consisted mostly of mash and oil. Grease analyzed 70% mineral oil. The Kane type of gas collector on the scum chamber of the tanks at Calumet has given good results. The gas production during the year averages 0.4 cu. ft. per capita.

The use of colloiders in the two-story tanks at Calumet does not justify continuance. Mohlman states that at Decatur, where the sewage is much stronger, it may be beneficial. The colloider is merely alternating aeration and settling in the flowing-through chamber. In the aerating section, lath baffles have been installed to increase surface area. This type of treatment is supposed to permit sprinkling filter rates up to 5 m.g.d. It produces fair results, but the cost is greater, at least for weak sewages, than other types of treatment.

Mechanical Clarification—All of the large clarification plants built in the east during the past three years have been of the Dorr type. Most of them are in connection with separate sludge digestion plants, which are described later. The clarification units installed at Chicago have not been entirely satisfactory. Contributing causes are the use of short-circuiting types of inlets and grit passed by the grit chambers. The rakes have been made longer, and half of the old ones have been removed. All of the sedimentation tanks visited could benefit by Pasadena's experience in type of inlets.

Practically all of the plain sedimentation tanks are new being equipped with scum removal equipment. A rather new development has been made at Aurora, where the scum is pumped to a steel tank, where it is allowed to settle and separate. The water under the scum is drawn off and only the concentrated scum is pumped to the digestion tank.

The plain sedimentation tank at Salem, Ohio, acts as a grease removal plant. The inlet channel has been enlarged to make it a combined aeration and grit chamber. The grease precipitated by the air is allowed to collect on the surface of the sedimentation

tank, and is removed by hand periodically, at a port near the flow line.

The Link Belt equipment for the clarifiers at Indianapolis is giving a fair clarification, but one can readily see that it needs improvement, for the concentrated material it is called upon to clarify. There is no doubt in my mind that the concentration of the sewage prior to sedimentation is one of the coming features in future clarification.

At Aurora, Illinois, the preliminary sedimentation tank has been covered. This greatly improves the appearance of the plant, controls odors, prevents wind disturbance, and in general gives a very good impression.

Progress In Sludge Digestion

Three years ago, on a trip east, I found only three small separate sludge digestion plants with mechanical removal of sludge, and none were equipped with gas collection and heating. There are now 59 separate sludge digestion tanks, with 66 digesters. Of the latter, 41 have gas collection and heating. This enormous increase shows clearly the present trend of sewage clarification and sludge digestion, and, in my mind, is an object lesson to engineers who still persist in designing works of an antiquated type.

The following list covers some of the larger plants employing gas collection and heating:

City	Population
Antigo, Wisconsin	12,000
Fond du Lac, Wisconsin	30,000
Aurora, Illinois	55,000
De Kalb, Illinois	25,000
Springfield, Illinois	60,000
Grand Rapids, Michigan	300,000
Toledo, Ohio (pending)	600,000
San Antonio, Texas	300,000
Fort Worth, Texas	225,000
Waco, Texas	75,000
Springfield, Missouri	55,000
Salem, Ohio	15,000
Peoria, Illinois (not yet built)	----------

So far, Dorr equipment has been installed on all large projects, including those above mentioned. Although their type of clarification equipment costs more than the Link Belt type and others, I am told the saving in more economical concrete construction, which the Dorr plant allows, has been giving, by actual contracts, a lower total first cost.

For eastern conditions, sludge must be stored at times for six months, and even though the sludge is heated an allowance of 1.5 cu. ft. per capita is made. In unheated tanks, an allowance of 3.0 cu. ft. per capita is now considered standard.

A good test of the advantage of sludge heating was experienced at Sioux Falls, South Dakota. The plant was put into operation without sludge heating in the winter of 1927-8. The sludge was acid, and caused trouble on drying. In the following winter the tanks were restarted, but the sludge was heated. No trouble was experienced with an acid sludge, and no lime was added.

It is important to drain the scum under the gas dome daily, until good digestion is established.

Digestion of sludge in open tanks at Baltimore has been very successful during the summer period. The scheme of operation is to leave one-third depth of old sludge for new fillings. Sludge is added, 1 to 2 feet daily, and good gassing continues, and by the time the tank is full its outlet or bottom sludge is ready to be placed on sand beds. Sludge is added under the surface, to prevent release of odors. When full, three soundings are made to determine the clear water zone, which is drawn off prior to the release of sludge. The digestion reduces volatile suspended matter from 75 to 55 p.p.m. in 24 days. About 50% of the sludge is lost through gassification and liquefaction. During the winter, sludge is recirculated to advantage. Heating of sludge, long experimented with at this plant, is in the future program. Further experiments on separate sludge digestion and heating are under way at the Chicago DesPlaines plant.

Digestion of activated sludge in a heated tank with gas collection has been installed at Salem, Ohio. Excess activated sludge pumped to the digestor gave an overflow liquor so bad that it bulked the sludge in the process, and spoiled the effluent. A separate settling tank was then installed in which the excess sludge was first pumped. After settling several hours, the clear water, amounting to three-fourths of the original sludge volume, is drawn off. The concentrated sludge when pumped to the digestor does not upset the clear water zone in it, and the overflow is clear.

Most of the heating coils are placed on the sides of the tanks and held in place by short screws and brackets. A more secure method of fastening should be employed to prevent dropping of the coils, which would

interfere with the rotation of the digestion equipment.

Many of the plants are equipped with auxiliary heating units, principally to get the plant started. This is a wise precaution for all new installations to adopt. Temporary steam boilers have been used in some instances.

Activated Sludge

Very definite progress has been made in activated sludge treatment, in obtaining greater efficiency at a less cost.

Advantage of Preliminary Sedimentation — Milwaukee is the only large plant not having sedimentation. Mohlman, a number of years ago, proved from experiments at Calumet, that preliminary sedimentation over screening would effect a 25% reduction in air consumption. Accordingly, the North Side plant was built with preliminary sedimentation. It is interesting to note that this plant is getting excellent aeration and nitrification with only 0.8 cu. ft. of air per gallon of sewage treated. The sewage is rather weak, although its suspended solids run as high as 110, and the B.O.D., 120 p.p.m. The aeration is so successful that good separation of sludge and liquid occurs one-third the way along the tank.

Both Salem, Ohio, and Indianapolis, claim to save air by use of preliminary sedimentation, and I believe now that it can be generally conceded as a necessary adjunct in activated sludge treatment.

Aeration—The Manchester type of aeration has certainly proven its worth. Milwaukee uses a ridge and furrow type, but the large masses of septic sludge which occasionally rise may be caused in part by the inefficiency of that type of aeration, even though the surface aeration looks fair. At Indianapolis the aeration seems to be rather violent. They claim, however, that violent aeration is necessary on account of their very concentrated sewage.

Following Mohlman's leadership, the activated sludge plants are now using the suspended solid test, aiming to keep 4000 p.p.m. of suspended solids in the aeration tanks.

Several of the new plants are using curved top baffles in connection with the Manchester type of aeration, to give the sewage a rotational flow. It does not appear that these specially curved plates are of any material advantage over the conventional designs.

At the Chicago North Side plant, water collects be-

hind the concrete baffles designed to give a spiral flow, and has a very obtectionable odor.

Experiments at Calumet, with short aeration periods of one hour with 15% of four-hour reaerated sludge prior to heavy dosing on filters, are not working out well because of the loss of too much poor sludge.

Mohlman has proven the need of reaeration of sludge for total plant efficiency. Neither Milwaukee nor Salem, Ohio, reaerate sludge. It seems to me that reaeration of returned sludge should be provided in new designs. Variable speed return sludge pumps work out well at Chicago.

I was much interested in the progress made with paddle-wheel aeration, as an adjunct to compressed air. This type of aeration originated with the Sanitary District of Chicago, at their Argo experimental plant in 1924, and is now being tested in a 1.8 m.g.d. plant, at Calumet. The sewage is first pre-settled, and then aerated in a wide tank, in which two horizontal paddles revolve downward toward air diffuser plates at each side of the tank. The amount of air now used is 0.2 cu. ft. per gallon of sewage. The total horsepower required per million gallons is 7 for compressed air, and 6 for the paddles, totaling 13; which is about one-half of the horse power if 0.8 cu. ft. of air per gallon of sewage were used alone. The final effluent of this treatment plant shows a final B.O.D. of 8 p.p.m. nitrates of 1 p. p.m., and 60% removal of organic nitrogen. Both Mohlman and Imhoff feel that much less air could be safely used. This is very encouraging, as this will cut down the present cost of activated sludge $6 to $10 per m.g.

At Salem, Ohio, a large demonstration is being made by the Dorr Co. with a paddle system in a tank which is only 9 ft. in cross section. Already their work indicates a saving at least equivalent to one-half of the present horsepower.

At Calumet, a chain-driven centrifugal blower with motor-gear reduction appears to be very dependable and satisfactory.

The advantages of washing the air used for compressing purposes, and removing oil from it to keep down the friction in the aeration plates, has been thoroughly demonstrated at Chicago and Indianapolis. At Indianapolis, the air is first passed through oil-removal filters prior to washing, which appears to be the logical procedure. At Chicago, the air is washed first, and then oil is removed. In both cases the air

friction in the diffusion plates does not build up, as at other plants. At Chicago, the air is heated prior to washing. Just what advantage this gives is not clear.

Final Sedimentation—Two outstanding developments in final sedimentation, have been the invention of the Tow-Brow clarifier at Milwaukee, and the use of double sedimentation at Salem, Ohio. The Tow--Brow clarifier is one in which a revolving arm at the bottom contains outlet nozzles which suck out sludge and some final effluent to the reaeration tanks. Experiments at Milwaukee indicate that for the same size of tank, 50% greater flow can be clarified than in other types of clarifiers. The clarifier was operating at this rate when I saw it, but the effluent was mediocre and contained particles of light sludge. Dorr clarifiers operating alongside were giving a good clarification.

At Salem Ohio, the final effluent, after being settled in a Dorr clarifier, is allowed to resettle in a plain sedimentation tank of the same capacity as the Dorr clarifier. This tank was made available from the old plant, and was put into use by the city engineer, primarily to act as a safeguard in case something happened with the plant proper. It is doing a great deal of work and is in continuous use. The tank has rectangular hopper bottoms which are cleaned every four days. This is done by decanting the top water and discharging the sludge on to sand beds. It is necessary to remove all sludge from the effluent, because of the character of the dry stream bed into which the effluent is discharged. The effluent from the Dorr clarifier looks like all activated sludge effluents, but the effluent from the secondary clarifier is noticeably clearer, and at once shows the advantage of the additional sedimentation. I believe that, in new plants, double sedimentation should be seriously considered.

The need of deep inlet baffles, such as at Pasadena, to prevent short-circuiting in the tank, was observed in all of the clarifiers seen in the east. The Indianapolis and Milwaukee design approaches this type of inlet.

The settling of activated sludge in plain sedimentation tanks is rapidly going out of date. Indianapolis is the only plant which attempts to do this. The tanks are circular and have rather steep hopper bottoms. A revolving arm with chains, presumably sweeps the sludge to the center outlet. Experiments with dyes, and looking down into the tanks through glases tubes, with lights below, show that, with all kinds and types of outlets, they cannot stop the bottom currents, which so defeat good sedimentation. The capacity of the en-

tire plant is seriously limited by this faulty provision for sedimentation.

Indianapolis has devised a good type of clarifier overflow. Everyone notices, on the weirs of clarifiers, that a small difference in head means a great variation in flow, particularly if some of the weirs are out of alignment. This is even more true when the clarifiers operate at full load. By putting in small V-notch outlets, 1½ in. deep, and 4 or 5 in. apart in the outlet weir plates, a little difference in head when the weir notches are out of level makes very little difference in the amounts discharged. I believe all the clarifiers will come to this type of outlet.

Sprinkling Filters, Dosing Tanks and Final Sedimentation

No large installations are being made of sprinkling filters. There has been a tendency in the larger plants in the East in the past to get away from patented equipment in connection with automatic siphons. At Brockton, Massachusetts, an attempt was made to vary the flow at the filters by turning on and off a valve in two separate lines, so that only one line at any one time would contain the flow, but, during the period it was getting the flow, the rate would be gradually increased, and decreased. This design did not work out well, because there is practically no overlap of the nozzle spray, and a large part of the bed is not wetted at all.

At Baltimore, a very good dosing arrangement has been devised. Each filter bed has its own feeder pipe and two are operated in pairs. The feeder pipe of each set lies one over the other, and each pipe has a butterfly valve in the lines, operating opposite each other. They are continually opening and closing as long as there is any flow through them. The operator manually controls the number of pairs in operation during the day, according to the sewage flow. This system certainly has worked out well, and, as it is not patented, it could be used elsewhere.

I was favorably impressed with the Columbus type of nozzle at the Baltimore sprinkling filter plant. It gives a longer distance of spray and much less trouble from cleaning. The spray drops are larger than with the Taylor nozzles.

There appears to be no type of clarifier yet worked out for efficient settling of sprinkling filter effluent. At Baltimore, where they have the largest sprinkling filter plant in the United States, the final tanks do

more damage than good. At Brockton, Plainfield, Aurora, Illinois and other plants, the same likewise applies. The effluent in all these cases loses dissolved oxygen and nitrates as it passes through the final settling tanks, and picks up large particles of sludge. It used to be stated that sprinkling filter plants in the east unloaded once or twice a year. They now find, probably due to closer observation, that there is more or less unloading continuously, as we have found in California.

The present type of settling tank was designed on the basis that the filters would unload once or twice a year, and that the sludge could be removed after digestion. With a continuous deposition of sludge in larger amounts than heretofore considered in the design, it is no wonder that these clarifiers do not give adequate removal.

Sludge Disposal

At present there seems to be no uniform procedure in removal of sludge from clarifiers, whether by pumping or by gravity. At the North Side plant, Chicago, outlet valves from the clarifiers are opened on predetermined cycles, through automatic operation by clocks, giving a gravity discharge for the sludge. This has not proved satisfactory, and they now find it necessary to install pumps to remove the sludge from the clarifiers. Experience elsewhere indicates that the types of pumps formerly used are not heavy enough for the work, and the Barnes pump in particular is to be made heavier. Centrifugal pumps for excess activated sludge have given away at Milwaukee to Worthington plunger pumps. Air and gases caused the centrifugal pumps to lose suction, and they claim the floc was also disturbed.

At Plainfield, New Jersey, an interesting discovery was made, namely: that by adding alum to sludge just as it is being put on to sand beds, it will dewater in four days, instead of requiring two weeks. The explanation is that carbon dioxide is released in minute bubbles from the chemical reaction of alum, making the sludge buoyant, so to dewater rapidly, in addition to the coagulating effect of alum itself. Experiments at Baltimore with alum did not prove this out, but it was admitted that the alum was not added just as the sludge was being applied to the sand beds.

The thought occurs: Why could not gas from the digestion works be mixed with sludge just as it is being placed on sand beds?

A good type of sludge bed cleaner is now being

perfected at the Calumet plant, Chicago. It consists of a rather large tractor type of machine, which cuts into the sludge at the rate of 1¼ sq. yd. of bed per minute, and then the sludge is transferred from specially designed elevators to belt conveyors which discharge it into cars. The equipment as now designed costs approximately $60,000, but in large plants, such as being designed at Chicago, such type of equipment readily pays for itself.

The price of sludge fertilizer at Milwaukee, for 130 tons daily, has been increased; now averaging $23 a ton. It is sold in three lots: retail, for lawn use at $40 a ton; wholesale, to fertilizer manufacturers in carload lots at $19 a ton; and wholesale, to anyone in less than carload lots at $26 a ton. The sale of sludge defrays all chemical, filter, and drying costs.

Chicago, in its experiments on hot house drying beds, finds that heating to prevent freezing of sludge, and ventilating to remove humidity, must be employed to secure a 50% better drying rate. Such beds cost $1 per square foot, and 6 months' sludge storage is cheaper.

The Oliver filtration of excess activated sludge at Milwaukee appears less successful than at Pasadena. The filter cake is spotty, thin, and has a water content never less than 84%. At the present time, about 390 gal. of 60% sulphuric acid is added to adjust the pH to 3.25, and 8 lb. of ferric chloride per 1000 gal. of sludge is added.

Permanent jets about 2 in. out from the drum, and both at top and near the cut-off plate, have been installed on the Oliver filters for washing. Hoods have been placed over these jets, and the washing operation is clean, with no splash.

That Atlas dryers have been speeded up by increasing and deepening baffles, lowering temperature, and adding to the oversize return. The inner core of the Louisville dryer has dropped three times and is not in good repute.

Miscellaneous

Promising experiments in grease removal are being conducted at the North Side laboratory, Chicago, which really amounts to filtering sewage downward through a 6 in. layer of light oil, in a tank giving but 5 min. detention. The depth is 6 times the diameter of the tank. The idea originated with the Centrifix Waste Recovery Co. of Chicago, and is well thought of.

Baltimore has a good ordinance on the garage oil problem. In addition to a good underground system

of inspection, the city collects regularly all oil from the garage. Prosecutions are made by the Fire Prevention Bureau. This drastic action followed a two-day fire in their oil-laden storm sewer.

A great many of the treatment plants are being troubled with highly nitrified effluent, causing algae and vegetable growth problems in small streams receiving their effluents. At Brockton, Baltimore, Salem (Ohio), and Chicago, very severe algae conditions are set up below the treatment plant, because of the fertilizing elements that the effluent contains. Practically all of these places are studying their algae problems, but do not know yet how to combat them. At Brockton, a suit was recently won by farmers below, because the increased vegetation in the channel caused the stream to overflow private lands.

In Massachusetts, three industrial plants have combined to jointly add 4800 lb. of sodium nitrate daily to the Neponset river, to prevent complete deoxygenation. It is the first case I know of artificial prevention of septic river conditions.

Odor Control

Milwaukee is chlorinating its dryer stack gases during such time as the wind blows from the lake to town. Over $100,000 is spent yearly on this. This treatment is effective. The dose required averages 100 lb. per day.

At Plainfield, New Jersey, where odor control is necessary because of lack of adequate isolation and treatment of an odorous sewage, they have resorted to a unique method of odor control. One of their Imhoff tanks is used to build up an activated sludge during the day, and from 3 p.m. to 10 p.m. one-third of the settled sewage is shunted through this tank on a detention period of 40 min. The effluent contains dissolved oxygen. During the time that the sewage is run through this tank, chlorine is added, giving a dose of 12 p.p.m. at the point of treatment, and a trace of free chlorine at the nozzle. Whether the dissolved oxygen in the effluent of the aeration tank, or chlorine itself, is responsible for odor control, is hard to state. However, when too much chlorine is added, they get an idioform smell ½ mile from the plant, indicating that probably chlorination is the most effective agent.

No other plants visited were using odor control, unless gas collection and burning could be considered under that score.

However, it was noticed that at none of the gas collection plants was the excess gas burned. In all

cases, it was vented to the roof. It does not seem to me that this method of disposal would be satisfactory or suitable for California conditions. At San Bernardino, when the gas is not being burned, it is very odorous. Burning is certainly necessary there. I believe it is desirable in all cases where odor control is imperative.

Results Obtained

In general, fairly good results are obtained by the treatment plants visited. The sprinkling filter plants are producing an effluent which is no better than our California plants. The activated sludge plants are slightly inferior. The effluents from both types of treatment processes are stable, contain quite a bit of suspended solids, have considerable color, and do not give a good impression to the casual observer.

The following table gives variations in suspended solids and B.O.D. for the raw sewage at a number of the plants inspected.

Plant	Suspended solids p.p.m.	B.O.D. p.p.m.
Baltimore	260	200
Chicago, North Side	110	120
Chicago, Calumet	120	75
Cleveland, West	227	163
Cleveland, East	183	98
Indianapolis	300	450
Plainfield, N.J.	230	
Salem, Ohio	240	

All of the plants with complete treatment remove about 90% of the suspended solids and B.O.D., except Plainfield, where the B.O.D. reduction is only 84%, and at Salem, Ohio, where 98% of suspended solids is obtained.

At Cleveland, 9 p.p.m. of chlorine gives 95% reduction of total bacteria and B. coli.

Clarification units are removing 25 to 90% suspended solids.

One of the most startling things I saw was at Chicago where John R. Bayliss at the experimental filtration plant, finds that by adding 3 gr. of alum per gal., and 8 p.p.m. of chlorine to the Calumet sprinkling filter effluent, he can remove all turbidity, taste, odor, and color except for chlorine, by passing through a sand filter. Then a second filtration through active carbon removes all traces of chlorine. The final effluent is truly crystal clear, sparkling as a pure diamond reflection, has a chemical analysis better than most acceptable drinking waters, and a taste like mountain

water. The oxygen consumed value is below 1.5 p.p.m.

Perhaps this opens up a further refinement for existing forms of treatment, especially where reclamation is involved.

Plant Control

Greater attention than ever is being given to plant control. Every small plant has its laboratory, fully equipped to make the more important tests. Many of the older tests are now being discontinued. Greatest stress is put on the B.O.D. and suspended solids tests. Next in order of importance are total organic nitrogen, ammonia by direct nesslerization, pH, and alkalinity. A good system of sludge analysis has been worked out at Chicago and is a great saving of time. Daily tests are made for water content and specific gravity. The residue from these tests is saved for weekly composite tests for volatile and fixed solids. These weekly composites are then saved and composite monthly samples are run for nitrogen and grease.

The development of home-made incubator rooms at Chicago for B.O.D. tests and special experiments, has proven a boon to the laboratory men.

Each plant now has accurate meters to determine the sewage flow. At the activated sludge plants, meters are installed to determine sewage flow, air for aeration purposes, air for other than aeration purposes, returned sludge, wasted sludge, and electrical current used. At the North Side plant, a very intricate method of chemical control is provided to regulate returned sludge and wasted sludge.

Mechanical control by operating the valves on cycles, such as operation of screens and opening of sludge valves, has been worked out at Chicago. At Milwaukee the Venturi meter has proven satisfactory, in that its openings are large, and there is less trouble from scale and condensate clogging the orifices.

Chicago has been working out some very excellent devices for continuous mechanical sampling of sewage sludge and final effluent. Not only is the sampling in proportion to the flows, but gives really a composite sample based on portions of the samples diverted every few minutes.

Good telephone and communication systems have been found advantageous at Baltimore. It simplifies the method of operation, reduces the number of operators needed, and gives the operators more confidence.

Tool houses conveniently located are a great assistance to operators. Likewise convenient operating gal-

leries and use of safety devices add to his comfort.

Good lighting systems with underground conduits and more spacious change rooms and quarters for the benefit of the operators are now provided.

Beautification of Works

The East has done a great deal in beautifying the plants. At the North Side plant, the works are laid out spaciously, and many of the parts of the plant, ordinarily left open, have been housed over. A monumental style of architecture has been used, giving the plant the appearance of a modern college campus. A good start has already been made in lawns and shrubbery. At Aurora, Illinois, the treatment plant looks like a California bungalow hotel, with stucco buildings and tile roof. The clarifiers and other works are housed. At Baltimore, over $3400 was spent merely for an entrance gate to the plant.

In general, the plants are well beautified. There are concrete roads. Lawns and shrubbery are well kept. At Salem, Ohio, the interior to the combined blower and pump house has been adorned with pots of ferns and bowls of gold fish.

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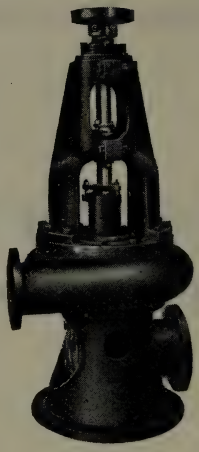

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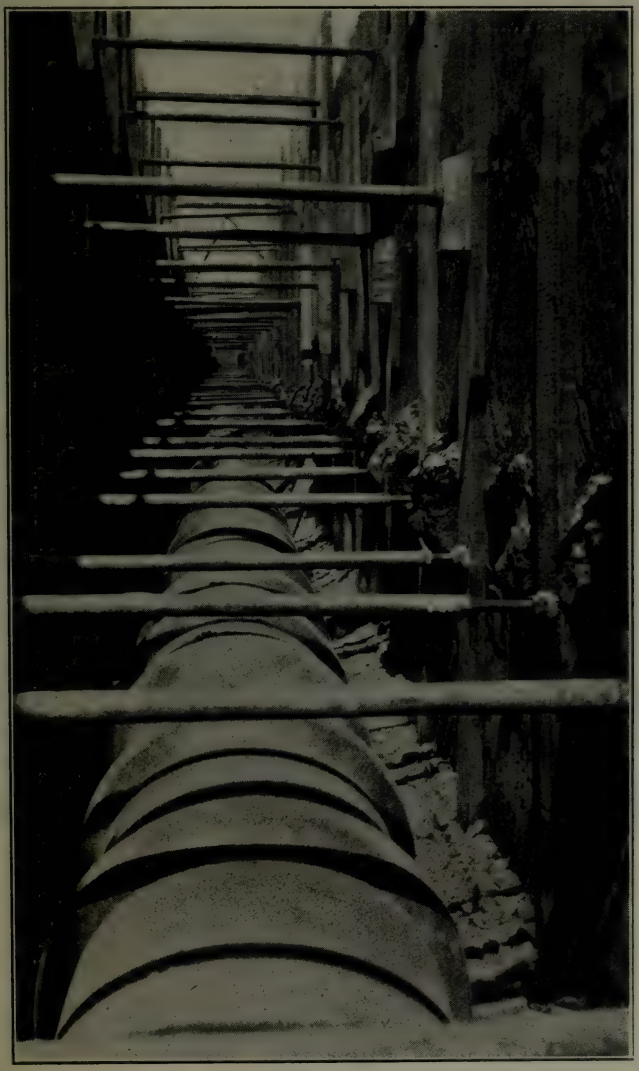

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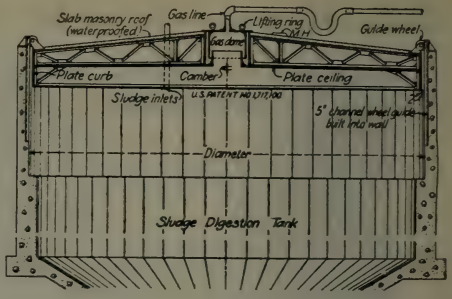

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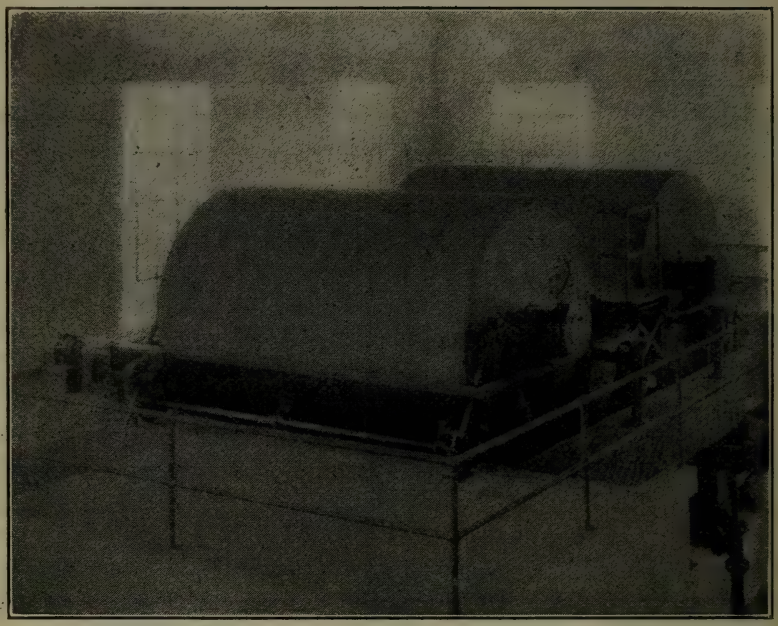

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CALIFORNIA SEWAGE WORKS JOURNAL

Official Publication of the California Sewage Works Association

VOL. III ✣ 1930 ✣ No. 1

Proceedings of the
Spring Conference at Sacramento
Third Annual Convention at Los Angeles

✣ ✣

Special Articles and Report
of the
Special Committee on Industrial Wastes

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APPLICATION FOR MEMBERSHIP

IN THE

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Date.....

(I) (We) hereby make application for membership in the California Sewage Works Association and enclose the sum of Two Dollars ($2.00) *for dues to December* 31, 1931.

Name .....

Title or Business.....

City or Firm.....

Address .....

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Send application to E. A. REINKE, ***Secretary-Treasurer, California Sewage Works Association,*** 3093 ***Life Sciences, Berkeley, Calif. Make checks payable to California Sewage Works Association.***

Acknowledgment

PUBLISHED *through the courtesy of Western Construction News and the firms who have given support to the Journal through their advertising. We hope all members of the C. S. W. A. will show their appreciation of this support when in the market for equipment or materials.*

CALIFORNIA SEWAGE WORKS JOURNAL

Address all communications to the Secretary
Membership and Annual Dues $2.00

This Journal, together with the Journal of the Federation of Sewage Works Associations, free to members. Extra copies, $1.00.

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Printed by
WESTERN CONSTRUCTION NEWS, Inc.
114 Sansome Street, San Francisco, California.

CALIFORNIA SEWAGE WORKS JOURNAL

Published by

CALIFORNIA SEWAGE WORKS ASSOCIATION

VOL. III 1930 No. 1

CONTENTS

Page

Officers and Committees - - - - - - - - - - - - - 4

Accomplishments and Objectives of the C. S. W. A. - - - - 5

Membership Data - - - - - - - - - - - - - - - 6

Program—Spring Conference, Ventura, March 23, 24, 1931 - - 7

Program—Spring Conference at Chico-Sacramento, April 21-22, 1930 8

Minutes—Spring Conference at Chico-Sacramento, April 21-22, 1930—(*with abstracted discussion*) - - - 9

Program of Third Annual Meeting, Long Beach, October 8-10, 1930 - - - - - - - - - - - - 16

Minutes of Third Annual Meeting and Inspection Trips - - - 17

Symposium on Odor Control.

Odor Control Through Design and Operation of Plants—J. Jacobson, Davis - - - - - - - - - - - - 21

Odor Control Through Design and Operation of Plants—Alva J. Smith, Los Angeles - - - - - - - - - - 23

Odor Control by Chlorination—L. L. Rose, Los Angeles - - - 26

Discussions - - - - - - - - - - - - - - - - 28

Financing Sewer Maintenance - - - - - - - - - - 31

Protective Paints - - - - - - - - - - - - - - 31

CONTENTS (*Continued*)

Symposium on Handling Sludge and Screenings.

Page

Handling Sludge and Screenings at Salinas—T. R. Haseltine - - 32

Handling of Sludge and Screenings at Long Beach—Herbert Paterson 39

Sludge Digestion at Joint Disposal Plant of Los Angeles County Sanitation Districts—A. Perry Banta - - - - - 41

Discussions - - - - - - - - - - - - - - - - - 44

Handling of Sludge and Screenings at Pasadena—A. W. Wyman - 45

Selling Activated Sludge Fertilizer in California—A. F. Thornton - 48

Selling Sewage Sludge as Fertilizer—C. Clay Kellogg - - - - 51

Symposium on Grease Removal.

Removal of Grease and Oils from Sewage by the Imhoff Method—Wm. A. Allen, Pasadena - - - - - - - - - - 53

Los Angeles Method of Grease Removal—G. A. Parkes - - - 55

San Diego County Keeps Grease Out of Sewers—G. C. Zuckweiler 58

Los Angeles Successfully Reclaims Sewage for Replenishment of Underground Water Supply—Carl Wilson - - - - - 60

Sewage Reclamation Plant for Los Angeles—R. F. Goudey - - - 65

Report of Committee on the Limitation of Discharge of Industrial Waste Into Sewers - - - - - - - - 78

Standard Report Forms - - - - - - - - - - - - 90

Summary of Replies to Questions on Root Troubles from '*Municipal Sanitation*' for December, 1930 - - - - - 92

Roster of Members - - - - - - - - - - - - - 96

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California Sewage Works Journal

The California Sewage Works Journal is not responsible, as a body, for the supposed facts and opinions advanced in any of the papers, discussions, or articles published in this Journal. Discussion of all papers is invited.

VOL. III 1930 No. 1

CALIFORNIA SEWAGE WORKS ASSOCIATION

ACCOMPLISHMENTS AND OBJECTIVES

The object of this Association shall be the advancement of the fundamental and practical knowledge concerning the nature, collection, treatment and disposal of sewage and industrial wastes, and the design, construction, operation and management of sewage works in California, through the interchange, between members of the Association and with others, of information, experience, and opinion relating thereto.

—Article III, Constitution C. S. W. A.

There is no question but that the California Sewage Works Association has made excellent progress in the three years of its existence—in membership, the dissemination of much worthwhile information and education of sewage plant operators, the creation of a state-aid sewage laboratory, enlightenment of municipal and state officials, and a general improvement in sewage treatment and disposal.

A fine start has been made, but there is much important work to be done—for instance:

Although the state-aid sewage treatment laboratory has been established in the Life Sciences building, University of California, Berkeley, in charge of E. A. Reinke, and is prepared to assist municipalities and sanitary districts in solving problems, the State Department of Finance has not provided sufficient funds for its efficient operation. The C. S. W. A. must bring pressure to bear on the Director of Finance, the Governor, and the State Legislature to make the necessary appropriation.

The State Board of Health is inadequately financed and manned to meet the ever-increasing calls which scatter its efforts. Apparently too it is devoid of sufficient police powers to properly enforce sewage purification, except where nuisance and menace to health can be shown. Further pollution of San Francisco bay should be immediately stopped,

and certain serious instances of present pollution corrected. The State Fish & Game Commission, Isaac Walton League, Associated Sportsmen, and Conservation Division of the State Chamber of Commerce will lend their valuable assistance provided the State Board of Health can take a decisive stand. In this case a strengthening of local demand for and appreciation of the benefits of a clean shore is in order. Individually and collectively the C. S. W. A. can be of service to the region and to the state. Apparently, the C. S. W. A. must appeal to the State Legislature to increase the funds and powers of the State Board of Health.

The problem of securing adequate funds for the maintenance of sewers and efficient operation of sewage treatment plants is becoming acute. At present this is subject to political jugglery and the uncertainties of the budget and tax rate. The C. S. W. A. must secure the passage by the State Legislature of a bill that will permit municipalities and sanitary districts to adopt sewer rental laws to permit of direct monthly sewer rentals.

More consideration is being given to the angle of water conservation, and this should accelerate interest in sewage purification. The press and the public will listen to this angle of sewage purification, whereas they are lukewarm on the sanitary angle.

The value of sewage sludge as a fertilizer has been definitely proved, as discussed in this issue of the Journal. Nevertheless, more publicity is needed to increase the demand.

There is much work to be done, and every member must do his part and not leave it to the officers to do it all.

PHILIP SCHUYLER.

A healthy increase in membership of the C. S. W. A. in 1930 is indicated by the following comparison of classification:

	1929	1930
City, county or state engineers	38. %	37. %
Consulting engineers	16.2%	16.5%
Operators and inspectors	10. %	16. %
Commercial men	14.4%	13.5%
Administrators	13.7%	7. %
Laboratory or research workers	3.7%	3. %
Miscellaneous	3.7%	7. %
Paid up membership	207	226

This shows a proportional increase in operators and decrease in administrators, with others about the same. As evidence that administrators are interested, however, the number of municipalities taking out memberships has steadily increased, 17 cities having taken out memberships either for the city or one of the officials.

It is hoped that more cities will join to make the organization a continuing group, give employees a chance to learn from experience at other places, and also provide a complete set of the Sewage Works Journals for use of the sewage works manager.

E. A. REINKE,
Secretary-Treasurer.

Spring Conference to be Held at Ventura March 23 and 24, 1931

Prizes for Best Maintained Sewage Treatment Plant

SPRING CONFERENCE

The board of directors at the annual meeting at Long Beach in October, tentatively selected Yosemite National Park as the best location for the Spring Conference. For various reasons, it was necessary to defer meeting at Yosemite and Ventura was finally selected as the meeting place.

The tentative program for this meeting follows:

Monday, March 23

8:00 a. m.—Meet at Santa Barbara.
8:30 a. m.—Santa Barbara State Hospital.
9:45 a. m.—Santa Barbara.
11:30 a. m.—Ventura.
Lunch at Ventura.
2:00 p. m.—Discussion of plants visited.
6:00 p. m.—Dinner and speaker, or discussion.

Tuesday, March 24

8:00 a. m.—Meet at Ventura.
8:45 a. m.—Santa Paula.
10:30 a. m.—Ojai.
Lunch at Wheeler.
2:30 p. m.—Discussion of plants visited.
Award of merit—Wallace & Tiernan bronze plaque.
Award of $25 cash prize.

Prizes

The board of directors will award the Wallace & Tiernan bronze plaque to the best maintained and operated sewage treatment plant during 1930. The first award of this plaque was made last year at Sacramento to the U. C. Farm sewage treatment plant at Davis, John Jacobsen superintendent. A cash prize of $25, donated by the manufacturer members of the association, was also presented to John Jacobsen. A similar cash prize will be awarded at the spring meeting.

PROGRAM SPRING CONFERENCE
APRIL 21-22, 1930
MONDAY, APRIL 21

8:15 a. m.....Chico. Assemble Hotel Oaks

8:30-9:45.....Chico Sewer Farm and Disposal Works

New plant with mechanically cleaned bar screens, clarifier with skimming, and separate sludge digestion with heating and gas collection.

9:45.....Caravan starts for Davis

12:45 p. m.....Lunch at University Farm, Davis

2:15-3:30.....U. C. Farm Sewage Disposal Plant

Two pumping plants, Imhoff tank, sprinkling filter, and final settling tanks. Operators' School. Use of tools will be demonstrated. Simple laboratory tests for settleable solids, pH of sewage and sludge, hydrogen sulphide tests.

3:45—Demonstration of measuring devices for irrigation water applicable to sewage or effluents. Weirs, gates, meters and Venturi flumes.

4:15.....Tour of farm showing lines of work carried on by University

7:00—Sacramento. Informal dinner, Hotel Sacramento. Round table discussion of plants visited and any questions brought up by members.

TUESDAY, APRIL 22

8:00 a. m.....Sacramento. Assemble east of Hotel Senator for trip to Lodi

10:00.....Lodi Activated Sludge Plant

Fine screen, activated sludge treatment, Dorr clarifiers and chlorination. Operators' School. Tests for sludge settling, free chlorine, methylene blue stability.

12:15 p. m.....Lunch. Guests of City of Lodi

1:45.....Caravan starts for Sacramento

3:15.....Sacramento screening and pumping plants

7:00.....Sacramento. Dinner at Hotel Senator

John W. Alvord, consulting engineer, Chicago, will speak on 'Biological Engineering.' Members of the Board of Directors, A. S. C. E. and Sacramento Section members will be present. Harrison P. Eddy of Boston will also give us a few remarks. A short business meeting will be held before the talks are given, at which an 'Award of Merit' will be given to the plant chosen by the Board of Directors.

SPECIAL NOTICE. All our members are invited to attend the spring meeting of the American Society of Civil Engineers, April 23-25, 1930. Headquarters at Hotel Senator, Sacramento. Programs and information can be obtained at headquarters.

CALIFORNIA SEWAGE WORKS ASSOCIATION*

Spring Conference at Chico, Lodi, and Sacramento, April 21 to 22, With Registered Attendance of 118—Review of Plant Inspections, Round Table Discussions, and Principal Addresses.

April 21, 1930

Members and guests of the California Sewage Works Association assembled at Chico April 21 to begin the 1930 Spring Conference. Under the direction of H. H. Hume, city manager, and M. C. Polk, city engineer, a 33-car caravan was taken to the new Chico disposal works and sewer farm.

Chico Plant—This plant is Dorr-equipped and has mechanically cleaned bar screens; a clarifier tank 50 ft. square, with skimmer and automatic screen; and a 40-ft. diam. separate sludge digestion tank with heating and gas collection. It serves a population of 8500 and handles 1,000,000 g.p.d., including the morning wash-down from a dry milk factory. The plant was built in 1929 for $55,000 and the entire improvements (6 miles of 18, 21, and 24-in. concrete pipe outfall sewer; 29 miles of vitrified pipe collecting mains and laterals, with bituminous joints; 200 precast concrete, 100 brick, and 6 special manholes; one double siphon on the outfall; and other items) totalled $262,656. Gogo & Rados,

Chico Sewage Treatment Plant.

Los Angeles, had the general contract and the work was sublet to W. J. Tobin, Oakland; C. Dudley De Velbiss, Oakland, later subcontracting the disposal works. All piping and valves in the plant were furnished by the Water Works Supply Co., San Francisco, and the vitrified pipe was furnished by Gladding, McBean & Co. and N. Clark & Sons. Effluent is ponded and used for irrigation of a sewer farm, the operator of this farm contributing about 2 hours daily to plant maintenance in return for use of the land and effluent.

*Reprinted from Western Construction News, issue of May 10, 1930.

Members of California Sewage Works Association on Sprinkling Filter at University of California Farm, Davis, April 21, 1930.

University of California Farm, Davis—Following inspection of the Chico plant and a description of its operation by H. H. Hume, city manager, the caravan proceeded to Davis, where lunch was served at the University of California Farm. At this time, Delvin Marshall, high school science teacher at Davis, presented three freshman students selected from a mixed class of 27 to read essays on the University Farm sewage disposal plant. These students, Myrtle Hamlin, Lucile Jacobson, and Cools, showed a commendable knowledge of and interest in sewage collection and treatment. The party then visited the two pumping and screening plants, Imhoff tank, sprinkling filter, secondary settling tanks, sludge bed, and irrigation checks for handling the sewage of 700 people and a large volume of barn manure and milk wastes. The disposal works are subject to larger flows of domestic sewage on days of club gatherings and demonstrations, when as many as 20,000 people may be present. The average total flow of sewage is 175,000 g.p.d. The system

Cork Elm Root 22 ft. Long, Removed from 4-in. Sewer (4 ft. Deep) at University of California Farm, Davis.

was described by its designer, H. B. Foster, University of California engineer, and a managers' and operators' school was conducted at the plant by John Jacobson, superintendent of construction at University Farm, assisted by representatives of the State Bureau of Sanitary Engineering. During the school, the use of tools was demonstrated (skimming the flowing-through chamber, determining depth of sludge, etc.) and simple laboratory tests were run.

Before leaving Davis, members of the caravan attended a demonstration of measuring devices for irrigation water applicable to sewage or effluents (weirs, gates, meters, and Parshall flume); toured the University Farm; and inspected some of the blooded livestock.

Sacramento Dinner and Round Table Discussion—An informal dinner was held at the Hotel Sacramento, F. A. Batty, president, presiding. After a short business meeting, a round table discussion was begun with the subject of 'Tree Roots in Sewers'. It was brought out by W. T. Knowlton, D. E. Perry, C. R. Blood, and Carl Wilson, that roots 18 ft. and more in length find their way into small diameter sewers laid with other than lead joints; that willows and elms are the worst offenders; that most of the trouble occurs in sewers laid above a 5-ft. depth; and that when ground water is high, roots do not seek sewer lines but the converse holds as the level is lowered.

On the subject of 'Manhole Spacing', discussed by F. A. Batty, C. C. Kennedy, Alva Smith, R. R. Ribal, and D. E. Perry, the maximum effective distance for rodding was given for manhole spacings of 300 to 350 ft.; on blocks 600 ft. long and with stoppages in the center, it was stated that rods cannot be used; stoppages were said to generally occur in sewers 8 in. diameter and smaller; lampholes between manholes were recommended on long blocks.

R. F. Goudey gave impressions of plants visited and trends in practice noted on his recent trip to sewage treatment works throughout the east. These impressions included: improvement in the line of mechanical equipment—detritors replacing grit chambers; increase in the use of separate sludge digestion with gas collection and heating; activated sludge plants turning to multi-stage treatment, sludge being aerated and settled as many as three times; double settling to get a better effluent; the tendency for too scant a capacity in clarifier design—with 500 gal, per sq. ft. or even lower capacity better results would be obtained; an automatic chlorinator which varies the feed with sewage flow and adjusts it to demand, whether constant or variable (this chlorinator takes a sample, adds the indicator, compares with a standard, and then feeds so as to keep the residual chlorine constant); economical removal of large amounts of phenol by adding ammonia and then chlorinating; production of a good effluent by removal of excess chlorine with active carbon. Goudey observed that no one treatment plant has thus far been developed which combines the best features of all plants; the Los Angeles Department of Water and Power has, however, recently completed an experimental plant with a capacity of 200,000 g.p.d., so flexibly designed that all schemes which look possible may be studied and economically compared.

W. L. Jencks described a new sewer joint which is simpler and more foolproof than the old type. In this joint a lip is placed on the end of the bell to serve as a retaining wall, lessening the danger of root penetration and ground water infiltration. H. N. Jenks, for some time an absent member, was welcomed to his first Association meeting. G. A. Parks argued for 'dressing up' sewage treatment plants constructed by bond issue and inviting public inspection so that future bond issues would stand better chance of favorable action. It was noted that a tendency exists in the east to dress up plants so that they will be most attractive and interesting to the eye.

April 22, 1930

Assembling at Sacramento, the caravan visited Lodi for an inspection of the city's activated sludge plant and attendance at an operators' school.

Lodi Plant—This plant was shown by J. F. Blakeley, city clerk, and F. W. Post, sewage works manager. It was designed by Clyde F. Smith and built in 1923 at a cost of $148,000; and has been visited by many. The connected population is 7500, but the plant has capacity to handle the sewage of 20,000 people. The sewage is highly diluted on account of flat water rates (average flow 130 and maximum flow of 160 g.p.d. per capita).

At this plant sewage passes a bar screen, goes through a quick-closing valve into a fine-screening chamber where it enters a 4 ft. diameter by 5 ft. Dorrco cylindrical screen, passes to a wet well, is lifted by Byron Jackson municipal pumps to influent channels where it mixes with activated sludge, and then enters the aeration tank which is divided into two units and equipped with filtros plates. The aerated mixture discharges to a settling tank from which the effluent passes over a weir to a chlorine mixing tank. Sludge is collected by a Dorr clarifier and forced into a sludge return channel where it is reaerated. An air lift mixes the sludge with incoming sewage. Screenings are buried and the sludge is dried on open beds and given without charge to farmers for fertilizer, 24 tons of sludge being drawn per year. The sludge is quite stable, has no disagreeable odor, and attracts few flies; effluent is used for irrigation.

During the managers' and operators' school, simple tests were run on raw and settled sewage and effluent, a hydrogen sulphide test was made, and pH determinations were illustrated. Members of the caravan were guests of the city of Lodi at a luncheon held in the Women's City Club, where they were welcomed by the mayor. Attention was called at this luncheon to the recent death of L. F. Barzellotti, city engineer and a member of the Association.

Before proceeding to Sacramento for the remainder of the program, a 2-hour side trip was made to Mather Field to view the maneuvers of the First Provisional Wing, Army Air Service.

Sacramento Pumping Plants—The two screening and pumping plants and 84-in. outfall to the Sacramento river were then shown by C. R. Blood, assistant city engineer, and Carl Hoskinson, chief engineer of the water and sewer pumping plants. The Sacramento sewer system has a connected population of 103,000, including the sanitary sewage of North Sacramento. It is a combined system, serving an area of 21 sq. mi., the maximum rainfall being 1 in. per hour. The city water supply is taken from the river 2 miles above Sump No. 1 (elev. 0 ft.) and 4 miles above Sump No. 2 (elev. −5 ft.). Sewage is screened and lifted from elev. −5 ft. to varying elevations of 0 ft. to +29 ft., depending on the stage of the river. The two plants have a total capacity of 364,000,000 g.p.d. In 1929 the total sewage pumped was 7,104,000,000 gal. against 8,722,000,000 gal. of filtered water—a ratio of 80% sewage to pumped water supply. In 1929, screens were cleaned 1042 times and 304 cu. yd. of material—much of it cannery wastes—removed and buried in shallow pits.

Closing Dinner at Sacramento—The Spring Conference closed with a dinner attended by 175 persons, including sanitary engineers assembled for the A. S. C. E. convention and representatives of the student chapters of the Society at California, Stanford, California Institute of Technology, and Nevada. T. E. Stanton, president of Sacramento Section, American Society of Civil Engineers, and J. S. Dean, city manager of Sacramento, welcomed the Association. President Batty explained the objects of and rapid growth of the C. S. W. A. and introduced John F. Coleman, president of the American Society of Civil Engineers, and the four student chapter presidents in attendance. An

award of merit for the best designed and operated plant was made to the University Farm, Davis, in the form of a bronze plaque, donated by Wallace & Tiernan Co., Inc.; a similar plaque to be presented each year. A cash prize of $25 was then given the operator of this plant, John Jacobson, this prize being donated by The Dorr Co., Great Western Electro-Chemical Co., Water Works Supply Co., and Western Construction News.

John W. Alvord, consulting engineer, Chicago (Alvord, Burdick & Howson), principal speaker of the evening, chose 'Biological Engineering' for his subject. Alvord remarked that the art of sewage purification commenced over 50 years ago and at about the time when he first began the practice of civil engineering. Early sewers led to water supply bodies —bringing the problem of separating sewage and water supply. Such treatment had its first development in England, a country of large cities and small rivers. Engineering can be classified as 'physical' and 'biological.' The former is mathematical in treatment, is based on the science of physics, and the engineer dealing with physical construction has been successful. Biological engineering deals with construction for water supply and sewerage, and the prevention of infectious diseases. Here enthusiasm and effort have met disappointment, as this branch of engineering has been a slow process of trial and error, trial and failure. The biological engineer can gather statistics but he cannot solve his problems by mathematical equation. He deals with the animate as well as the inanimate and therefore needs more and better judgment and a wider reach and grasp of scientific facts than does the physical engineer. In general principle, the biological engineer knew 50 years ago what he does today, the application and refinement of his processes remain. For example: since 1888 engineers have looked for an economical fertilizer from sewage waste. Also, sewer gas—a long known by-product—was one considered dangerous but is now being used for speeding the process of separate sludge digestion in cold climates. Enough gas can be gathered from a connected load of 30,000 to 40,000 persons to not only warm the sewage, but to heat and light the plant and be put to public use for partial street lighting, etc. The placing of mascerated cornstalks in a digestion plant will greatly accelerate gas production. Thus, a Corn Belt farmer may heat and light his home. Alvord concluded his remarks with a humorous poem of unusual merit, entitled 'Nutshell Philosophy'.

Harrison P. Eddy, consulting engineer, Boston (Metcalf & Eddy), was the other notable guest and speaker. Eddy traced the differences in knowledge and conception of underlying principles of sewage treatment from the work of Franklin in England, beginning in the 1880s. He cited the disappointment from failure to properly understand and recognize the principles in the intermittent sand filter, until its purpose and use with other processes later became established. He described the process by which sewage is pumped into a treatment plant, digested and decomposed to produce gas, the gas carefully piped and tapped to prevent explosion, and the tank contents heated with steam produced through the burning of this gas. Eddy asserted that the sewage works operator of today has a most difficult position since (a) the disposal of

municipal wastes is the last thing in which the public takes any interest; (b) it is hard to secure adequate funds for extension, maintenance, and a qualified staff; (c) there is divided responsibility in the governmental function; and (d) the operator must sell his board of supervisors the need for adequate support. Eddy concluded that such an association as the one in session can perform helpful work in gaining the support of municipalities for plant operators.

1928 JOURNAL

The Secretary, E. A. Reinke, continues to receive requests for copies of the 1928 Journal, and he will be glad to pay $1.00 per copy for any copies which the members care to send him. Some of these requests are from libraries and foreign agencies and should be supplied if possible.

1929 JOURNAL

The Secretary has a number of extra copies of the 1929 Journal on hand, which will be mailed upon request to prospective members, etc.

PROGRAM THIRD ANNUAL MEETING OCTOBER 8-10, 1930

Headquarters: Hotel Breakers, Long Beach

WEDNESDAY, OCTOBER 8

9:00 a. m.....Business meeting and election of officers

10:00 a. m.—Papers:

ODOR CONTROL.

(a) Design and Operation—John Jacobson, U. C. Farm, Davis. Discussion by H. B. Hommon, H. N. Jenks, Alva J. Smith.

(b) Chlorination—L. L. Rose, City of Los Angeles. Discussion by F. S. Currie, R. L. Patterson, R. F. Goudey.

11:00.....General Discussion

12:00 Noon—Lunch as guests of Pacific Clay Products Co. at Los Nietos plant, followed by inspection of pipe.

2:15 p. m.....Visit to Pasadena Activated Sludge Plant

4:00—Visit to Griffith Park Experimental Plant of Los Angeles City Water Department.

THURSDAY, OCTOBER 9

8:00 a. m.....Visit to Hyperion Screening Plant

9:30—Visit to Poggi Ranch Plant, Los Angeles County Sanitation District.

10:45—Demonstration of Sewer Cleaning at Wilmington by Los Angeles City.

12:00—Noon—Lunch at Hotel Breakers, Long Beach. City Engineers and Street Superintendents section of League of California Municipalities will be invited to attend. Mayor A. E. Fickling will speak and officially welcome us to Long Beach. Informal discussion.

2:00 p. m.—Papers:

1. HANDLING OF SLUDGE AND SCREENINGS.

(a) Digestion—T. R. Haseltine, Salinas; A. P. Banta, Los Angeles Sanitation Districts; Herbert Paterson, City Engineer, Long Beach. Discussion by R. F. Goudey, M. C. Polk, D. C. McMillan, Ray Burgess.

(b) Fertilizer—A. C. Daley, Pasadena. Discussion by A. S. Thornton and H. Clay Kellogg.

2. GREASE REMOVAL.

(a) Imhoff Method—W. A. Allen, Pasadena.

(b) Los Angeles Method—G. A. Parkes, Los Angeles. Discussion by G. C. Zuckweiler, San Diego.

4:00—Visit to Long Beach Screening Plant and Pico Avenue Pumping Plant.

6:30—Banquet, Hotel Virginia, League of California Municipalities. Program, entertainment and dancing to follow. See further details in League Program at Long Beach.

FRIDAY, OCTOBER 10

Trip to Catalina Island as guests of City of Long Beach.

NOTE: Members must register with League at Hotel Virginia for this trip and for Banquet Thursday night.

MINUTES, THIRD ANNUAL CONVENTION

OCTOBER 8 AND 9, 1930

Meeting called to order by President Batty

Membership Committee—Phillip Schuyler reported that members of his committee had worked indivdually; he had used the Western Construction News for publicity, and in particular R. F. Goudey had influenced many members to join. Present membership is 224.

Industrial Wastes Committee—No report.

Publicity Committee—Alexander Bell reported that before the spring meeting he sent out copy to northern California newspapers from San Francisco and A. K. Warren sent it out from Los Angeles to Southern California papers, but only about five per cent of the editors availed themselves of this copy. From experience at the spring meeting he felt personal contact would produce better results than newspaper publicity and suggested that commercial men in their travels could easily mention the Association and stress the necessity of city officials having representatives at the meeings. Warren agreed with Bell on personal contact, but suggested that individual members on their return home give the local newspapers an account of what took place at the Long Beach meeting. He also suggested that all members do what they can to contact city officials and not leave it up to commercial men alone. Schuyler stated that in attempting to get publicity for a state-aid laboratory he had run against a stone wall, but noted recently a new mosquito abatement district in Alameda County got 'lovely' publicity over the killing of some thirty billion mosquitoes. He thought items of local interest could be given by the local man to his home town paper.

Editorial Committee—E. A. Reinke reported that work done was the same as previously. The 1929 Journal was published and the 1930 Journal under way. He asked for suggestions for additional material.

Legislative Committee—B. J. Pardee stated that no report had been prepared.

Auditing Committee—F. D. Bowlus reported books in satisfactory condition and balance on hand of $85.05.

Award Committee—A. M. Kivari read the report in the absence of Chairman Reynolds, asking that the award be delayed until the spring meeting to allow better opportunity for systematic method of granting the award. President Batty approved the extension of time.

Standard Report Forms Committee—A. M. Rawn presented two summary cost forms which will be printed in the 1930 Journal.* The committee felt it undesirable to present detailed cost sheets at this meeting. He suggested that a committee be continued until spring to try out the forms with various plants and operators and see what results may be obtained. He also suggested for the committee that the Professor of Sanitary Engineering of Stanford, the Professor of Sanitary Engineering at California and the Chief Engineer of the State Department of Public Health be appointed as a committee to select not less than three nor more than five plants each year to be submitted to the Board of Direction of the Association and they to canvass the plants with standard forms before making the final award.

*See Page 91 for Report Forms.

Third Annual Convention, California Sewage Works Association, Long Beach, October 8 and 9, in Front of Breakers Hotel.

Moved by A. J. Smith, seconded by W. A. Allen, and unanimously carried that the forms committee as constituted be continued to the spring meeting.

Nominations Committee—A. M. Rawn reported the following:

For Director—F. A. Batty, Los Angeles.
President—B. J. Pardee, Visalia.
First Vice-President—W. A. Allen, Pasadena.
Second Vice-President—John Jacobson, Davis Farm.

Secretary-Treasurer—E. A. Reinke, Berkeley.

Moved, seconded, and carried that nominations be closed.

Moved, seconded, and unanimously carried that the secretary be instructed to cast unanimous ballot for those named by the nominating committee.

Treasurer's Report—E. A. Reinke presented a written report showing cash on hand of $85.05. This amount is less than a year ago but there are no hold-over bills this year.

Secretary's Report—E. A. Reinke presented a written report showing 224 members, an increase of 17 over last year.

No further business appearing, a five-minute recess was declared.

A paper on 'Odor Control by Design and Operation', written by John Jacobson of the U. C. Farm, Davis, was read by C. G. Gillespie, and discussed by Messrs. E. M. Hilton and A. J. Smith.

A paper on 'Odor Control by Chlorination' was read by L. L. Rose of Los Angeles and discussed by F. S. Currie, R. L. Patterson, R. F. Goudey, H. H. Hall, A. M. Kivari, W. T. Knowlton, C. A. Smith, and Philip Schuyler.

Carl Wilson, of the Los Angeles City Water Department, in discussing cost of sewage treatment, stated that he believed in arid country, at least, reclamation of water could be made to pay all or a large part of the cost of sewage treatment. In reply to a question by Philip Schuyler he stated that sewage could be considered as the waste or by-product of the water works industry, and the property of the water works man.

The meeting was adjourned at 11:30 a. m.

Luncheon and Afternoon Session, October 8

A caravan of 46 cars was formed and members visited the Pacific Clay Products plant at Los Nietos, where manufacture and testing of pipe was demonstrated. A delightful luncheon was served by the company with music furnished by an employees' band.

The caravan proceeded to the Pasadena activated sludge plant, which was explained by superintendent Wyman and assistant superintendent Allen; then to the experimental plant of the Los Angeles City Water Department, which was explained by R. F. Goudey, sanitary engineer.

Morning Session, October 9

A caravan of 28 cars was formed at Hyperion screening plant of the City of Los Angeles, which plant was explained by J. H. Van Norman and his staff.

The caravan proceeded to the Los Angeles County Sanitation District plant at Poggi Ranch, which plant was explained by assistant chief engineer A. M. Rawn.

The trip was continued to Wilmington, where a maintenance crew from the City of Los Angeles, under F. A. Batty, demonstrated various methods of sewer cleaning.

Luncheon and Afternoon Session, October 9

A group of 105 assembled at the Hotel Breakers, Long Beach, for lunch. Mayor A. E. Fickling was guest of honor and officially welcomed the Association to Long Beach. Following the meeting a group photograph was taken.

The afternoon session was called to order by President Batty.

Papers on 'Handling Sludge and Screenings' were read by T. R. Haseltine of Salinas, A. P. Banta of the Los Angeles County Sanitation Districts, and Herbert Patterson, city engineer of Long Beach. Discussions were given by R. F. Goudey, M. C. Polk, and D. C. McMillan.

A paper on 'Handling Sludge and Screenings' was read by A. W. Wyman, of Pasadena, stressing fertilizers. The paper was discussed by A. S. Thornton, who sells 'Nitroganic', from Pasadena, and by H. Clay Kellogg, who handles 'Sludgeon,' from Los Angeles County Sanitation Districts, Pomona, Whittier, San Bernardino, and Orange County sewage treatment plants.

Papers on 'Grease Removal' were read by W. A. Allen on 'Imhoff Method', and by G. A. Parkes on 'Los Angeles Method'. A written discussion by G. C. Zuckweiler was not read because of lack of time, but will be published in the Journal.

W. T. Knowlton presented a resolution extending thanks to the Mayor, City Council, and Chamber of Commerce of the City of Long Beach; the Pacific Clay Products Company; the Vitrified Clay Pipe Manufacturers; and the retiring officers of the Association for their work in bringing about a successful meeting. The resolution was amended by Chester Smith to include the city engineer of Long Beach. Another resolution concerning legislation for sewage maintenance was also presented.

Moved by Mrs. Christensen, seconded by Don E. Perry, and unanimously carried that both resolutions be adopted.

Philip Schuyler thanked the Association for the gift of golf clubs and bag presented to him following the spring meeting, and pledged the continued support of Western Construction News.

President Batty turned the meeting over to President-elect B. J. Pardee, who expressed thanks for the honor and asked assistance of the members to make the Association the greatest of its kind.

Meeting adjourned. Following the meeting a group of members visited the Long Beach screening plant and one of the sewage pumping stations, under the guidance of Herbert Paterson, city engineer.

Respectfully submitted,

E. A. REINKE, Secretary-Treasurer.

ODOR CONTROL THROUGH DESIGN AND OPERATION OF PLANTS

By J. Jacobson*

I can only speak about experiences I have had at the city of Davis and at the University Farm sewage treatment plants.

In 1907, the University built a sewer system which included septic tank, manholes, sewer lines, and pumping plant. This complete unit was built at a cost of $16,000. The University at that time had practically no buildings. This was considered a fine septic tank in 1907, but received a number of criticisms from farmers in this locality, for the State having spent so much money for underground sewer construction. The septic tank had been in operation for two weeks when the inspector noticed a man washing his arms in and drinking the effluent, and called his attention to the fact that this was sewage. We thought it quite complimentary that the effluent could not be distinguished from fresh water.

This septic tank was composed of two compartment-tanks and a pumping pit. The pump was installed in a wet pit at the time and this proved very unsatisfactory. In later years, we had a dry pit installed and the pump removed to it.

The amount of domestic sewage was small. The creamery wash was nearly two-thirds of the total amount, together with a small amount of barn sewage. This tank, after operating for nearly four years, had considerable odor. The odor increased, due to the fact that in the creamery sewage a great deal of raw acids were dumped directly into the line. The installation of the tank was evidently wrong, because we had considerable odor each time the pump was in operation and it could be noticed for half a mile away. The sewage was used for irrigation during the summer months and during the winter time it was left to flow out upon the land.

We had a good many complaints about this tank, due to the odor, even noticeable on the highway and in the city. This tank was in operation about nineteen years. After a number of years the tank was practically surrounded by agricultural buildings and a large growth of eucalyptus trees, nearly hiding the tank, which did not help our conditions.

The University Farm, in 1926, installed a new sewer system at a cost of $50,000. The plant and system were designed by H. B. Foster, engineer for the University of California. It is not necessary to describe in detail the operation of the system since practically all members of the Association inspected the plant last April.

The system consists of two pumping plants, sewer lines, manholes, Imhoff tank, settling tanks, and a filter bed.

The University has three types of sewage; domestic, creamery, and barn, such as horse, sheep, cattle, and hog barns. Of these different sewages, we find that the amount of creamery sewage is now approximately one-quarter. This type of sewage, being very strong, produces

*Superintendent of Repairs and Power, U. C. Farm, Davis.

conditions causing strong odors, which are satisfactorily handled by the ventilating system and constant flow in the line. Our sewage is kept fresh by well-ventilated fixtures, ventilated manholes, and pump houses. The sewage in the first pumping plant is pumped at least every 15 minutes, so that sewage is not more than 2 hr. and 20 min. from the time it leaves the building fixtures until it has gone through the tanks.

The Imhoff tank at this time is 2½ miles from our campus, and we have never noticed any odor within the campus nor have we had complaints from the outside. Once each day both pumping plants, the equalizing chambers, and siphons are inspected. Bar screens are cleaned and walls washed down to prevent the accumulation of waste material and to keep the walls free from scum, etc. We believe this to be an important factor in odor control.

We believe for a small sewer system that our Imhoff tank and its operation is entirely satisfactory.

The city of Davis installed a new sewer system in 1920 at a cost of $50,000. This included the sewer lines throughout the city, manholes, one pumping plant, and 3000 lin. ft. of 8-in. pressure line to the Imhoff tank, with a rise of 14 ft.

The Imhoff tank consists of one flow chamber, two scum chambers, one automatic siphon, and a filter bed, approximately 40 by 120 feet. The pumping plant consisted of two 4-in. Byron-Jackson pumps. In this pumping plant they allowed storage capacity of several thousand gallons, but after it was installed a great deal of trouble was experienced in the breaking of the pressure lines and five vents, each 35 ft. high, were installed. This tank gave considerable odor which was also noticeable a half-mile away from the pumping plant. They operated for approximately nine years under these difficult conditions, such as bad odor and line breaks. This year, or at the present time, they have changed their outfall system, doing away with the storage capacity, picking up the raw sewage every 15 min., installing 3000 ft. of 12-in. gravity line, adding one pumping plant and equalizing chamber, similar to the one of the University Farm outfall. This new line is a 12-in. line with a grade of 1.5 ft. per 1000 ft. The pumping plant is operating at this time, although not complete, and is proving satisfactory and nearly odorless. This design was copied from the University Farm sewerage system which has proved satisfactory since 1926. We believe that Davis has made an excellent change, due to the fact that their sewage from the time it leaves the home fixtures until it goes through the septic tank does not exceed two hours.

ODOR CONTROL THROUGH DESIGN AND OPERATION OF PLANTS

By Alva J. Smith*

The matter of controlling the odors that are generated in processes of sewage disposal has increased greatly in importance within the past few years. The increase in the demand for odor control in recent years has outstripped the general demand for sewage disposal. A demand for odor abatement in plants already constructed has been brought about by the improved processes of sewage treatment that have been adopted in the modern, recently constructed, disposal works. The later methods are not only able to remove a large percentage of the repulsive organic content of the sewage water, but to reduce the organic matter that is removed to a harmless state, all without the production of objectionable odors. This having been satisfactorily accomplished, one of the liveliest problems remaining for the sanitary engineer to solve is to remove from the public mind memories, and past impressions made by malodorous sewage disposal works.

Morris Cohn has stated the problem very plainly in his article on "Sewage Works Odors and their Control", in Sewage Works Journal, Vol. 1, No. 5, Oct., 1929. He says: "Production of satisfactory unit efficiencies may satisfy the State Department of Health, and the turning of a fine effluent into our streams may satisfy the Isaac Walton League, but there is still another social group that must be satisfied". He refers to the residents of the sewage disposal plant neighborhood. In the same article he refers to the three 'C's' of odor control—care, clean-lines, and chemical treatment—to which I will suggest the addition of another 'C' for common sense.

The use of chlorine for odor control has been widely studied and quite generally adopted, particularly on long outfall lines. This treatment has for its basis the prevention of the formation of hydrogen sulphide, which is probably the most notorious offender among the various gases that are produced at a sewage disposal works. The beneficial effect of chlorine is mainly due to the destruction through oxidation, of certain bacterial life, that has as one of its functions the splitting of the sulphate molecule and the release of hydrogen sulphide. Aeration has a similar effect, and in some cases is fully as efficient and often more economical than chlorine. This is said in full recognition of the very large and legitimate place that chlorine will continue to fill in the field of sewage disposal in the future. In confirmation of this I am submitting some figures taken from a recent report made by Smith-Emery Co. on the analysis of gases generated in the sludge digestion tank at Escondido.

*Manager Los Angeles office of Black & Veatch, Consulting Engineers.

Laboratory Certificate

SMITH-EMERY COMPANY

Chemical Engineers and Chemists, 920 Santee Street, L. A.

Date, Oct. 3, 1930.

Laboratory No. 121270.
Sample Gas—Received 10-3-1930.
Submitted by Black & Veatch, Escondido, Calif.

ANALYSIS

Carbon Dioxide (CO_2)	19.4%
Unsaturants	None
Air	5.0%
Hydrogen (H_2)	None
Carbon Monoxide (CO)	None
Methane (CH_4)	74.6%
Ethane (C_2H_6)	None
Hydrogen Sulphide (H_2S)	None
Nitrogen (N_2)	1.0%
	100.0%

Heating value 752 B. T. U.

Respectfully submitted,
SMITH-EMERY CO.,
Chemists and Engineers.
E. O. S.

The effect of thorough aeration given the sewage in the activated sludge process of treatment, seems to be carried over into the sludge digestion tank. The resulting gases liberated in the digestive processes at Escondido are entirely free of hydrogen sulphide, as shown by the accompanying report. Practically 75% of this gas is methane (CH_4). The gas has a heating value of 752 b. t. u. and a market value of 75 cents per 1000 cu. ft. As the amount of combustable elements contained in this gas is large, it makes it an easy matter to eliminate the odors carried, by burning in the open air. However, at Escondido, the heating value of the gas is to be conserved for heating and lighting of the residence of the plant superintendent on the grounds, and perhaps by piping it to the municipal swimming pool for heating purposes.

As an odor-control measure quite generally adopted, the odor foci around a plant are covered. The housing of screens, settling tanks, sludge digestion tanks, and even sprinkling filters has become quite common. A better understanding of the processes of sludge digestion has, in the newer plant at least, resulted in the design of equipment which permits complete digestion of the sludge, and thereby eliminates the odors sometimes given off in sludge drying. Gas collection, and incineration of screenings, is now a common practice.

In the design of plants, care should be exercised to avoid pockets, corners and places where sludge or scum may collect and remain long enough to develop putrifactive odors, and in their operation cleanliness is an important matter. The free use of a hose daily, especially on the

walls of tanks above the water line, is necessary if odors about a plant are to be avoided.

In order that the development of odoriferous products about a plant be held to a minimum it is necessary that the sewage be treated as fresh as possible. Long and poorly constructed sewer lines where the suspended matter may become lodged, and the stranded material be subjected to anaerobic decomposition for hours before reaching the plant, are often causes of odor difficulty. The end of the outfall sewer being at the plant, odors developed within the sewer will naturally find an outlet there. Frequent flushing of the sewers and prechlorination of the effluent are perhaps the most effective remedies that have been applied to this condition.

As stated near the beginning of this discussion, one of the live problems claiming the attention of the sanitary engineer is the removal of a morbid prejudice from the public mind. People know what they expect to see, and smell, when they visit a sewage treatment works. If you will keep your plant clean and free from odors, and confront your visitors with a beautiful park, green grass, and flowers tastefully arranged, it will go a long way toward convincing the public of the success of your undertaking.

ODOR CONTROL BY CHLORINATION

By L. L. Rose*

During recent years there has arisen, in connection with the operation of various sewage treatment plants, a considerable of trouble from odor nuisance. The problem is frequently one of operation, but recent developments have indicated that much of the difficulty can be anticipated and practically eliminated.

The many different odors emanating from sewers and sewage treatment plants are frequently caused by various gases from industrial wastes. The most serious, from the standpoint of odor nuisance, is hydrogen sulphide.

Hydrogen sulphide gas is very volatile, foul smelling, and far reaching. It can be dissipated and carried for great distances by light winds, and is very disagreeable when present in even small quantities. The nuisance is greatest at night, when becoming cooled, the gas lies close to the ground and is rolled along and spread over large areas. This gas tends to follow valleys and depressions, becoming quite obnoxious to people whose homes are in its path, and neighbors are generally resentful of the odors and even of the works themselves.

Important factors to be considered are: the time of concentration of sewage, which may be increased by long laterals and mains; flat grades; obstructions or accumulated solids in the sewers; or intermediate lift stations. Contact with relatively stagnant sewage or with masses of decomposing organic matter in the collecting system results in a seeding of the fresh sewage, with the consequence that septicization occurs much sooner than would normally develop under good conditions.

When sewage is collected in a wet well and pumped after it reaches the plant, the retention period in the well allows additional time for the sewage to become more septic. Particularly is this true if the well is irregular in shape, permitting sewage solids to collect in the corners or around the edges. Such a condition in the pump pit could be anticipated and eliminated by building the bottom of the collecting well on a good grade, sloping toward a small sump, in which the pumps have their suctions, and so designed that dead spaces are excluded and the entire floor scoured each time the sewage is pumped. Thus quite frequently it is possible to reduce odors by changes in the plant.

The most practical means by which odors may be eliminated is the use of chlorine gas to control the rate of multiplication of the hydrogen-sulphide organisms. Chlorine, which is a powerful disinfecting agent, does this very effectively. It not only kills the hydrogen-sulphide organisms present in the sewage and retards their subsequent development, but when hydrogen-sulphide has already been produced ahead of the point of chlorination, the reaction is one of odor destruction.

With these thoughts in mind, plans were made to control the odor present at one of the pumping plants of the city of Los Angeles, on Manchester Avenue, near Figueroa, which was placed in operation in January, 1921. At that time this plant was somewhat isolated, but with

*Assistant Engineer, Bureau of Engineers, City of Los Angeles.

the march of progress it is now surrounded with modern markets, bungalows, and apartments.

The pump well in this plant is circular, with a diameter of 24 ft. The sewage enters the plant 20 ft. below the ground level through a coarse bar screen, flows along entrance channels, and drops 10 ft. into the wet well below.

Two vertical sewage-pumps, each having a capacity of 1800 g. p. m., with their suctions 8 in. above a small sump, lift the sewage through a force main into a trunk line which delivers the sewage to the treatment plant at Hyperion.

The sewage inflow at the pumping plant is 2,000,000 gal. per day, and fills the pit in 12 to 15 min. Therefore, during filling and pumping periods gases are released into the atmosphere with a resulting odor nuisance.

To combat this odor a solution-feed chlorinator was obtained, and experiments to control the odors were started in February, 1930.

A small limestone tower was used, built from a barrel and filled with ¾-in. crushed limestone, weighing 92 lb. to the cubic foot. A solution line from the chlorinator entered the barrel through the bottom. Water was fed to the tower under 20 to 40 lb. pressure, mixed with 8 lb. of chlorine, which acted on the limestone and produced hypochlorous acid. This mixture was fed through hose and hard rubber pipe to the pump pit and dry well where it was released through hard-rubber sprays, two in the pump pit and one in the dry well—the three feeding 4½ gal. of liquid per minute. These sprays atomized the acid and filled the chambers with hypochlorous gas, which is quite destructive to metalic surfaces. This gas killed the odors fairly well, but not completely, so a vent from the top of the pump pit was carried to a point 150 ft. back of the plant. Fumes were carried through a 12-in. vitrified clay-pipe to a stack 30 ft. high, with a gas burner in the bottom. Gas was burned to consume as much of the odor as possible, but principally to heat the escaping gases so as to help them rise to a greater height. On an average, 500 cu. ft. of gas was consumed in 24 hours.

The results of these experiments were so encouraging that the city purchased a new chlorinator in July, which is more modern and far more efficient. New sprays were installed and the limestone tower was placed on the roof, which produced more pressure at the sprays and released more hypochlorous gas. After these sprays were put in use, the odors were practically controlled. Some of the people who had previously complained now stated that the odors were no longer noticeable.

Lead acetate test papers were used to detect the presence of hydrogen sulphide at three or four stations throughout the plant, while the chlorine or hypochlorous gases were detected by iodine and starch test strips. Most of the hydrogen sulphide detected was directly under the top floor and in the building.

At present the old wooden floor is being replaced by one of concrete, and while the pits are exposed, the chlorinator is delivering 15 lb. per 24 hours, and test papers show no hydrogen present in the building. Tests taken at the stack show a trace of sulphide, so it is being considered to wash the gases in a specially constructed chamber before they enter the vent stack.

In addition to the foregoing, the wet well is washed out once a week by a crew of men, to get rid of any solid matter that may have lodged on the bottom. The sides and top of the pit are also scoured at that time.

The cost of treatment at present is $1.25 per day or $0.63 per million gallons. The limestone used averages two pounds per day.

SUMMARY

1. Objectionable odors from sewage plants are caused chiefly by hydrogen sulphide.
2. The production of hydrogen sulphide occurs in sewage having a high sulphate content, and is facilitated by long laterals and mains having flat grades, and in other places by contact with accumulated masses of decomposing organic matter or mixing with septic liquor.
3. Odors can frequently be materially reduced by correcting conditions at the plant.
4. Chlorine destroys hydrogen sulphide in definite proportions, thus helping to destroy an odor nuisance.
5. Definite odor reduction can be obtained.
6. Odors are most severe in the evening, from sundown to 10 P. M., and the maximum dosage should be maintained during these hours.
7. Hypochlorous acid is very destructive to metalic surfaces, and all metal that it comes in contact with should be protected.

CHLORINE DATA

Chlorine, a greenish yellow gas, was discovered in 1774 by Scheele, a Swedish chemist.

Atomic weight	35.46
Molecular weight	70.92
Liquifies at —33.6° C. or	—28.48° F.
Solidifies at —102° C. or	—151.6° F.

	Gaseous Chlorine	Liquid Chlorine
Specific Gravity	2.491 (air = 1)	1.4405 (water = 1)
Weight of 1 liter	3.167 grams	1440.5 grams
Weight of 1 cubic foot	0.198 lb.	89.922 lb.
Weight of 1 gallon	0.026 lb.	12.022 lb.

One volume of liquid chlorine is equivalent to 454.9 volumes of chlorine gas.
One part per million = 8.34 lb. per million gallons water.
= 0.058 grains per gallon.
One grain per gallon = 17.12 parts per million.
= 142.86 lb. per million gallons water.

DISCUSSION

By L. H. Enslow*

Mr. Rose has presented a very interesting description of the experimental application of hypochlorous acid as a means of destroying odors emanating from sewage. Chlorine water first applied from the spray heads was objectionable because of its irritating effect on the eyes of the operators and the likelihood of corrosion difficulties.

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The experimental application of hypochlorous acid produced by a modification of the well-known 'Kellner Process' was an attempt to destroy odors without the objectionable features attendant upon the chlorine-water process.

The 'Kellner Process', developed and patented in Austria in 1894, consisted in passing chlorine gas upward and water downward through a tower of crushed limestone. At the Manchester avenue station chlorine water from a chlorinator entered at the bottom of the tower and was discharged at the top. In this procedure the chlorine is converted to hypochlorous acid and calcium chloride in accord with the following reaction, which in practice requires roughly 0.9 lb. of limestone or marble per pound of chlorine fed.

$$2Cl_2 + CaCO_3 + H_2O = 2HOCl + CaCl_2 + CO_2$$

The extent to which this reaction proceeds to completion is dependent upon such factors as time of contact between chlorine water and limestone, temperature, quality of limestone, and surface of limestone exposed. In making use of limestone towers for hypochlorous acid production a material of high purity (approximately 98% $CaCO_3$) and small size (¼-in. diam. or finer) as recommended by C. T. Henderson, appears to be a very satisfactory material.

Hypochlorous acid when sprayed through the atmosphere above the sewage will react with ammonia and other gases there present. Sulphur bearing compounds are destroyed and ammonium chloride and chloramines are produced in accordance with the following reactions:

(a) $H_2S + HOCl = H_2O + HCl + S$
(b) $NH_3 + HOCl = NH_2Cl + H_2O$
(c) $NH_3 + 2HOCl = NHCl_2 + 2H_2O$

The important reactions are (a) and (c), although (b) may to a limited extent take place. Excess hypochlorous acid breaks down to produce nascent oxygen and hydrochloric acid which in turn reacts with ammonia to produce ammonium chloride.

(a) $HOCl = HCl + O$
(b) $NH_3 + HCl = NH_4Cl$

To completely avoid every corrosion difficulty inherent in the use of hypochlorous acid it may prove advantageous to substitute calcium-hypochlorite solution produced continuously if possible by mixing chlorine and lime emulsion. In this case the continuous feeding of hydrated lime replaces the limestone in the reaction tower. The location of the spray heads will be important because the air must either pass through, or mix with, the spray of hypochlorite at some point, if deodorization is to be complete. Probably the most efficient and economical scheme, in many instances, will be to vent the wet well through the roof and place the spray nozzles within or across the entrance to the stack. The regulation of proportions of lime to chlorine need not be exact. Ordinarily it is desirable to feed from 1 to 1.25 lb. of lime per pound of chlorine applied.

The use of hypochlorous-acid sprays for odor control at this Los Angeles pump station has been an interesting innovation and constitutes a promising development. So far the indications are that the corrosion difficulty justifies additional experimental work with finer limestone or hydrated lime. One or the other should materially improve the practical aspects of the process if it does not increase the efficiency of odor control.

The correctness of this assumption is attested to by the records of performance during the first few days after the installation of the original limestone tower (February, 1930) by F. A. Batty, assistant chief engineer in charge of pumping stations and outfall sewers, under the supervision of J. J. Jessup, city engineer. After the 'fines' in the ungraded limestone had been consumed, the remaining material—¾-in. or larger—reacted very slowly, only about 2 lb. per 24 hr. being consumed, as reported in Rose's paper.

R. F. Goudey remarked that the subject was just about three years old and was gaining a lot of headway because, as previous speakers testified, it could be made to work. Certain principles must be observed: first, mineral sulphates must be present; second, is effect of temperature; up to 65° F. there being little need for chlorination. When temperature reaches 85° F. hydrogen sulphide production is prolific. Industrial wastes may cause seasonal high demands and increase temperature. Addition of lime prior to chlorination in some cases will bring about marked economy. Use of chloramines, chlorophenols, and copper sulphate may have merits. Chlorination is established but refinements to lower cost of operation may be expected.

F. S. Currie discussed chlorination experiences at the San Bernardino Imhoff-tank trickling-filter plant. Chlorine may be added at the upper end of an inverted siphon 6500 ft. from the plant, at the inlet to the plant and at the inlet to the dosing chambers. Experience has indicated most effective results are obtained by chlorinating at the upper end of the inverted siphon and at the dosing chambers. A total of 80 lb. per million gallons is added, of which 75% is applied ahead of the inverted siphon and 25% at the dosing chambers. Chlorination should be done before hydrogen sulphide has formed. Provision for storage and facilities for easy handling are important. At San Bernardino, 18 cylinders are stored horizontally and also placed horizontally on scales by use of an overhead monorail system. This takes up considerable room. A new design at Newport Beach includes handling containers on end.

R. L. Patterson, city engineer of Newport Beach, stated that during the last year the pump operator had handled chlorination, that the property owners were satisfied, and that he had not given much personal attention to it during the year. (See 1929 Journal, p. 172).

A. M. Kivari, in reply to a question by H. H. Hall, stated that prechlorination does not effect sludge digestion.

W. T. Knowlton announced that Los Angeles had just completed arrangements for testing a sewage flow of six to ten million gallons daily.

FINANCING SEWER MAINTENANCE

Chester A. Smith introduced this subject when he stated: that in addition to common 'sense' in operation as afore-mentioned by Alva J. Smith, common 'cents' were necessary.

Philip Schuyler discussed funds for maintenance and supervision of plant operation and suggested that engineers include in bond issues a specific sum for maintenance and research during the first year of operation of plant. For example an item of $5000 in a bond issue of $200,000 would readily be voted, whereas even $100 for maintenance from the general fund looks large to a city council, and is difficult to get.

W. T. Knowlton stated that on advice of the city attorney of Los Angeles they could not use money from a bond issue for maintenance. He suggested that the Association do something to permit assessment of large contributors to city sewers.

Carl Wilson suggested the possibility of sewage reclamation with revenue sufficient to pay cost of operation. Replying to a question by Schuyler, he said he felt that water works men should consider sewage a waste from their industry and should reclaim it—disposal being incidental to reclamation.

PROTECTIVE PAINTS

Replying to a question by E. A. Reinke, Carl F. Tennant and J. H. Van Norman stated that aluminum paint gave best results on wood and metal. W. A. Allen said good results had been obtained with non-metallic base paints.

HANDLING SLUDGE AND SCREENINGS AT SALINAS

By T. R. Haseltine*

Prior to this spring the city of Salinas discharged its sewage into the Salinas river in a practically untreated state. In the past an attempt had been made to run the sewage out on a sandy area at the river before it entered the main channel, but the flow of sewage had gradually increased until the sandy area was entirely too small. A fruit and vegetable cannery in the city discharged its wastes into a drainage canal that runs through the northern portion of the city. This canal is dry during most of the cannery season. The firm of Burns-McDonnell-Smith Engineering Co. was engaged by the city to make a survey of its existing sewage system and recommend improvements. Our investigations showed that high grade treatment of the sewage was necessary to protect the river, and the activated sludge process was selected as being most suitable to the local conditions. When cannery wastes are combined with the sewage they add greatly to the expense and difficulty of treatment by this process, and inasmuch as these wastes were already separated from the sanitary sewage it was deemed desirable to keep them so. It was decided, therefore, to remove the suspended solids from the cannery wastes at a small pretreatment plant adjacent to the cannery, after which they would be pumped into a storm sewer, carried to the river and filtered on the sand beds previously used for sanitary sewage.

From the foregoing it may be seen that Salinas has two entirely different types of sludge to handle; namely, that produced from the domestic sewage and that produced from the cannery wastes. These two plants were completed last May. Since that time I have been engaged in assisting the city in the operation of these plants and training the city's operators.

Cannery-Waste Treatment Plant

Design—The cannery-waste treatment plant is the first of its kind in the state, and for that reason it will be described in some detail. The wastes first pass through a bar screen with ¾-in. clear openings, and then through a 3 by 3-ft. Dorrco screen. This screen is covered with 20 mesh monel metal fabric. After screening, the wastes are settled in a radial-flow clarifier, 20 ft. diam, and 8 ft. deep, equipped with a Dorrco center-drive sludge collecting mechanism. The sludge is pumped into a 3000-gal. elevated redwood tank from which it is hauled away. A 3-in. two-part, Fairbanks-Morse, sewage pump of 50 g. p. m. capacity is used to pump the sludge. The suction piping is so arranged that the sludge may be pumped directly from the bottom of the clarifier or from a small sludge sump adjacent to the clarifier. When pumping directly from the clarifier, the pump is started and stopped by a time clock, the time interval being 90 min. The running time can be varied from zero to 54 min. When pumping from the sludge sump the pump is operated by a float switch. When the sludge sump is used, the sludge enters

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continuously from the clarifier through a draw-off pipe swiveled so that the elevation of its outlet may be varied, thereby controlling the rate of sludge removal. A wooden arm floating on the surface of the clarifier can be pulled around the tank, thereby crowding the scum into a hopper which discharges into the sludge sump. Screenings are collected in buckets of 3½ cu. ft. capacity. A chain hoist and trolley is provided to facilitate their handling. The entire plant is housed in a corrugated iron building. The cost of the plant, exclusive of land, was $12,127, which was borne by the city, while the cannery furnished the site for the plant.

Fig. 1 (Upper). Floating Roof of Digester at Salinas.
Fig. 2 (Lower). Interior of Digester.

Operation—In return for the city building the plant, the cannery greed to operate it. The plant was first put into operation during the pricot pack and ran under the cannery's operation for the duration of ie apricot pack and the first two weeks of the peach pack. At no time id the cannery taken the proper care of the plant; they failed to haul vay either the screenings or the sludge as often as required, and made tle or no effort to keep the clarifier free from scum. After receiving veral odor complaints from residents along the route of the storm wer that received the wastes, the city decided to operate the plant itself id charge the cannery the actual cost of such operation. The cannery greed to this arrangement. The following data on plant operation are ken from the city's period of operation.

From August 30 to September 12 the cannery handled an average

of 70 to 75 tons of peaches and 35 to 50 tons of tomatoes a day. No accurate measure of the volume of wastes handled is available, but it is estimated that the flow averaged 200 to 250 g.p.m. for the 15 or 16 hours a day that the cannery operated. Table I gives analyses of a composite of hourly samples of the influent and effluent on a typical day. Catch samples taken at other times showed both higher and lower results.

Table I.—Peach and Tomato Wastes

	Influent	Effluent
Residue on evaporation	3780 p. p. m.	2344 p. p. m.
Volatile matter in residue	78.7%	69.8%
Suspended matter	589 p. p. m.	299 p. p. m.
Settleable solids	76 cc/liter	15 cc/liter

About 300 lb. of screenings and 5000 gal. of sludge and skimmings were removed each day, disposed of on the city's garbage dump. The sludge was very watery and either seeped into the dump or spread out so thin that it dried before giving offense. One sample of sludge showed 97.6% moisture and 97.5% volatile matter on a dry basis. However, not all of the sludge was this dry, and it was further diluted by the skimmings, so that the sludge that was hauled away probably averaged between 98 and 99% moisture.

When handling peach wastes it is essential to keep the clarifier alkaline to obtain good results. The lye used in cleaning peaches will normally keep the wastes alkaline if the clarifier is kept fairly free from sludge, but when the cannery was packing nearly as many tomatoes as peaches the waste was less alkaline when it left the cannery and we had more scum form and got poorer removal of suspended matter in the clarifier.

Since September 12, the cannery has been operating on tomatoes and pears. Analyses of the influent and effluent on September 16 are given in Table II. On this day the pack was only 13 tons of pears and 57 tons of tomatoes. About 400 lb. of screenings and 3500 gal. of 98.8% moisture sludge were produced, which contained 82.8% volatile matter on a dry basis.

Table II.—Tomato and Pear Wastes

	Influent	Effluent
Residue on evaporation	1390 p. p. m.	1227 p. p. m.
Volatile matter in residue	67.2%	69.7%
Suspended solids	261 p. p. m.	57 p. p. m.

The normal tomato pack at the Salinas cannery is about 200 tons per day, so it may readily be seen that the foregoing data do not give a true idea of the normal strength of tomato wastes. However, our brief experience indicates that tomato wastes are much easier to handle than peach wastes. With continual sludge removal there is no scum formed and at least 90% of the settleable solids can be removed. The volume of sludge produced does not vary directly with the pack because when more tomatoes are canned a drier sludge is obtained.

The plant is operated by one man who also hauls away the sludge in a 750-gal. tank wagon. The labor costs for operation are about $9 per day. Power costs are not known because power is furnished by the cannery without a separate metering, but at any event it is not great.

Sanitary Sewage Plant

Design—The sanitary sewage first passes through a bar screen with 2-in. clear openings, and then is pumped to the primary clarifier by 6-in. Fairbanks-Morse two-part sewage pumps. The primary clarifier is equipped with a Dorr traction type sludge collecting and skimming mechanism. The average detention period in the primary clarifier is 1.4 hr. for the present sewage flow. Sludge is drawn by gravity from the clarifier to a sludge sump from which it is pumped to the digester by a Barns Odofor pump. The skimmings from the clarifier go either to the sludge sump or to separate scum beds. The digester, which has

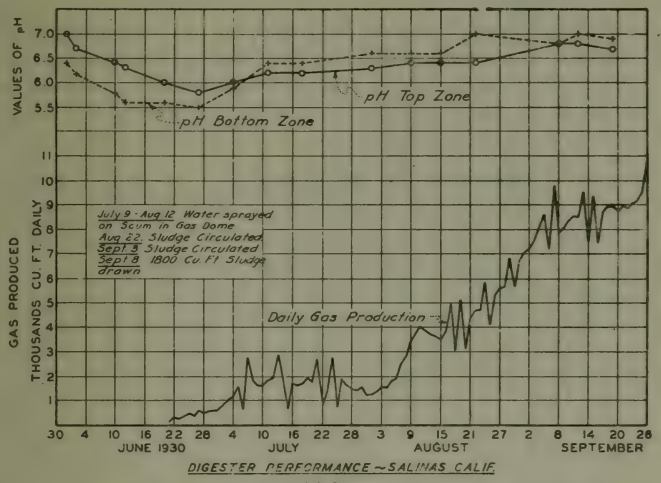

FIG. 3.

some unusual features, is shown in Fig. 1 and 2. It consists of a circular tank 55 ft. diam. with four hoppers in the bottom, each 19 ft. square at the top, 3 ft, square at the bottom and 7 ft. deep. The roof rests on eight columns placed around the interior circumference of the tank. The roof is a concrete slab, the center of which is slightly higher than the peripheral, hung from steel beams encased in concrete. A concrete wall around the circumference of the slab extends 3 ft. 9 in. above the slab and 2 ft. below it. There is a 3-in. clearance between this wall and the inside of the tank. This roof is entirely free from the supporting columns and when the digester is filled it floats upon the sludge liquor. The maximum rise of the roof is 2 ft. The total depth of the digester from the bottom of the hoppers to the under side of the roof when it is at its maximum is 19 ft. The capacity of the digester is 33,325 cu. ft., or about 3.2 cu. ft. per capita for the present ppoulation. So far as I know this is the only floating-digester roof west of the Mississippi and the only one in the country built of concrete.

There is a gas collection dome in the center of the roof, and the gas is metered and then burned to control odors. Gas is also piped into the laboratory and into the residence of the operator adjacent to the plant. Sludge sampling devices are placed over each hopper so that samples from any depth may be obtained. Sludge enters the digester

through a 4-in. pipe riser in the center of the tank that extends up to within 9 in. of the bottom of the roof when it is resting on the columns. Sludge is withdrawn through four 8-in. pipes, one of which originates in each hopper. Sludge may be drawn from the bottom of the hoppers to the sludge sump and be pumped back into the digester, thereby circulating the sludge in the digester for seeding or pH control. The digester is surrounded by an earth embankment. Two coils of 2-in. cast-iron pipe for circulating hot water were placed in the digester. This pipe is brought out through the embankment and capped so that in the future a boiler may be installed and the sludge in the digester may be heated. The overflow liquor from the digester is returned to the inlet of the primary clarifier.

There are four sludge drying beds with a total area of 12,500 sq. ft.; equivalent to 1.2 sq. ft. per capita for the present population. The remainder of the plant consists of the conventional Manchester type aeration tanks and Dorr equipped final clarifiers with accompanying equipment.

Operation: Character of Sludge—The average sewage flow is 606,000 g. p. d. or 59 gal. per capita per day. The raw sewage has 315 p. p. m. suspended matter, 350 p. p. m. 5 day B. O. D., and a pH value from 7.0 to 7.2. The primary clarifier removes 48% of the suspended matter and 29% of the B. O. D.

To date there has been only a small amount of excess activated sludge pumped to the digester. Most of the sludge handled by the digester has been primary sludge. A few analyses of primary sludge are given in Table III. It is estimated that the bulk of the sludge pumped to the digester had an average moisture content of 97% to 98%. Its pH ranged between 6.0 and 6.5. Most of the sludge contained about 70% volatile matter on a dry basis. However, a break in the sewer which caused a large amount of mud to enter the outfall during the latter part of July caused the volatile matter to drop to as low as 20% for a period of two weeks.

Table III—Primary Sludge Analyses

Date	Moisture contest %	Volatile matter % dry basis	pH
June 2	98.8	70.1	6.2
June 7	96.6	66.5	6.0
June 12	93.4	69.2	5.8
June 21	90.0	72.1	6.0
August 6	89.1	73.7	5.8
August 8	87.9	52.1	
September 8	91.5	72.6	6.4
September 17	91.8	68.9	6.2

Starting the Digester—Sewage was first turned into the plant May 8, and after two days the plant was by-passed. Sewage again passed through the plant May 16 to 19. On May 24 sewage was again turned into the plant and has been going through the primary clarifier continuously since that time, except for a few days at the last of July when the plant was by-passed because of the aforementioned break in the sewer. Each time the plant was by-passed the primary clarifier was pumped out into the digester.

The digester was filled to the bottom of the roof on June 2, and to the overflow on June 6. At the time it contained 6000 gal. of well water, 90,000 gal. of raw sewage, and 153,800 gal. of quite dilute sludge and scum from the primary clarifier. The pH in the bottom hoppers was 6.4 on May 31. During the next 13 days it dropped to 5.6, after which it remained practically constant for 15 days and then gradually rose during the next 66 days to 7.0. Since then it has remained between 6.8 and 7.0. The pH of the supernatant liquor was 7.0 at the start. For 28 days it gradually dropped to 5.8, after which it rose less rapidly than did that of the bottom sludge. It now remains slightly lower than the pH of the sludge. No lime was used. Fig. 3 shows the pH at the top and bottom of the digester at various times. On August 22 the bottom sludge had a pH of 7.0 while that 8 ft. up had a pH of 6.6. About 150 cu. ft. of sludge was drawn from the bottom of each hopper and recirculated. This procedure was repeated twelve days later. The overflow liquor from the digester remained quite clear for 70 days, after which it became quite black due to small particles of sludge. When the digester was first filled this overflow contained 20 p. p. m. hydrogen sulphide. In 20 days the hydrogen sulphide content dropped to 12 p. p. m. Since then it has gradually decreased to 1 p. p. m.

The ash content of the bottom sludge in the digester has increased quite rapidly, due partly to digestion and partly to the high mineral content of the sludge handled during the two weeks following the aforementioned break in the sewer. The first sludge was drawn 98 days after the digester was filled. This sludge was practically free from odor and contained about 30% volatile matter. The maximum depth of sludge on the beds was 9 in., which cracked within two days, and formed a porous cake that could be removed after 10 days.

Gasification—Very slight gasification was noticed as soon as the digester was filled. It required some adjusting of water seals and pressure regulators before all the gas could be measured, but on the 15th day after the digester was full we had all adjustments made and metered a flow of 164 cu. ft. Since that time the gas yield has gradually increased, as shown by Fig. 3, to more than 10,000 cu. ft. per day, or 1 cu. ft. per capita per day. From the start the temperature within the digester has remained practically constant, ranging between 70° F. and 70 and 75° F. Thirty days after the digester was filled it was noted that the gas came in surges of one-half to two minutes duration, with periods of no flow of from one to five minutes between surges. An inspection showed a heavy scum on the surface of the liquor in the gas dome. Water was jetted onto this scum for 30 min. to 4 hr. a day through four ¾-in. pipes in the top of the gas dome that had been provided for this purpose. This procedure was followed for 40 days, at which time the gas yield had reached nearly 4000 cu. ft. per day. Since then we have had a practically constant flow of gas throughout the day. An inspection of Fig. 3 will show that the first time sludge was circulated it resulted in an increase in rate of gas production, but that the second time no such effect could be noted. It is probable that the second circulation was not necessary. One great advantage of the floating roof is the fact that sludge may be drawn without affecting either the quality or quantity of gas produced.

In closing, I wish to call attention to the fact that both of the plants described in this article have been in operation only a short time, and as operation continues there will probably be considerable change in the average results obtained. At the time this article was written we had had only two weeks experience with tomato wastes. At a later date we will be able to give more complete information on the handling of these wastes. Under normal operating conditions considerable excess activated sludge will be pumped to the digester at the main plant. Just what effect this will have on the operation of the digester, remains to be seen.

Salinas Sewage Treatment Plant, Showing Primary Clarifier, Blower House, Final Clarifier and Aeration Basins.

HANDLING OF SCREENINGS AT LONG BEACH

By Herbert Paterson*

Briefly stated, screenings are handled at Long Beach screening plant as follows:

The solids retained by the Dorr screens are caught in perforated buckets on a slow-moving elevator and dumped into a pneumatic ejector, from which they are raised by compressed air to a covered measuring hopper above the incinerators, and after being weighed are again blown by compressed air directly into the furnaces and there burned.

The journey from the screen pit to the ejectors is made on an endless chain of perforated buckets traveling at a rate of 12 ft. per min. This slow speed affords an opportunity of draining the water off, although the transfer only takes 1¼ min. and is the only time during which the screenings are exposed to the air. It is to this short exposure that we attribute the small amount of odor which is to be found around our disposal plant.

It might be well to mention here our method of cleaning the screens. Formerly the slots, which are 1/16-in. wide by 2-in. long, would gradually clog up on the under side, with the grease in the sewage retarding the flow and decreasing the amount of water handled through the screen. It was necessary once a week to take the screen out of commission and thoroughly clean it with a wire brush on the spindle of a portable grinder, a day's job for an 8-ft. screen.

We have now installed over each screen a 2-in. water line with a short length of hose and a nozzle working under a 60-lb. pressure.

By directing this jet over the screens at night when the flow is low and the water pressure high, we are able to operate for 60 days without wire-brush cleaning.

From the elevator buckets the screenings are dropped into a pneumatic ejector pot which holds 1000 lb. of screenings. When the pot is full the lid is closed by a hand lever, compressed air turned in, and the screenings are blown through a 6-in. castiron pipe to the weighing hopper on top of the furnaces, a lift of about 18 ft. This weighing hopper is a circular steel tank with a sealed cover and has a capacity of 5 tons.

When the contents have been weighed, compressed air is turned on and the screenings blown directly on to the furnace grates. The size of the charge varies with the time of day and the quantity of sewage flow. It will be readily understood that when one charge is completely destroyed, another charge must replace it immediately in order that the furnace does not stand empty. Consequently, the charges vary in size. A fair sized charge is 3000 lb., which will take about 4 hr. to burn. At present we are handling about 9 tons of screenings per day in 6 charges.

Our daily flow of sewage is 10,000,000 gal. and the amount of screenings fluctuates from 1850 lb. to 2350 lb. per million gallons, the average being 2100 lb., with a moisture content of 90 to 92%; and the

*City Engineer.

yield of ash after incineration 50 lb. per million gallons or 2½% of th weight of the screenings burned.

The incinerator is constructed with grate bars in the front half o the furnace and a solid floor in the back half. Two Premix gas burner under air pressure enter the front end of the furnace. The burning i entirely from the top and the method is as follows:

The fresh charge lies on the grate bars, draining and heating fo approximately 30 min.; the water drained being returned to the scree pits. As the top begins to burn, the operator pushes it back onto th solid floor, working off the top every 30 min. until the whole charge completely burned up.

The ashes are then removed before a fresh charge is inserted. Th burning is continuous throughout the twenty-four hours and there a two furnaces, one in operation and the other being a standby.

The ash has some value as a fertilizer and is entirely used on th gardens surrounding the plant. The Park Board is also glad to get and many private citizens come with sacks and take away a small quantit for their private gardens.

A chemical analysis gives the following results:

Phosporic acid	4.07%
Potassium Oxide	0.35%
Ammonia	0.54%
or a total fertilizer value	4.96%

With this system we are able to burn 1 lb. of screenings wi 1½ cu. ft. of gas. It is to be noted, however, that our gas is natur with a heat value of 1200 b. t. u.

The cost of incineration of screenings is difficult to estimate closel The men who attend to the furnaces do other work and the gas co in our particular case is low as the city owns the gas system. T closest approximation I can make is as follows:

Daily consumption of gas—24,000 cu. ft. @ 15c	$3.60
Energy of blower per day	.50
Wages—1-3 of 1 man's time for 3 shifts	6.50
Total outlay	$10.60

Amount of sewage handled—10,000,000 gal.
Cost of incineration per 1,000,000 gal. of sewage....$1.06
or practically $1.00 per ton of screenings.

In conclusion, the incineration of screenings while more costly th other methods of disposal, is a clean and sanitary method. The screenin are disposed of without offense, nuisance, or menace to health. utilizes a smaller space than any other method and there is no residu to be taken care of. At present the daily sewage flow is about 10,000,0 gal., consequently, our bill for incineration amounts to $3,900 a ye It might be possible to save one-half this sum by changing the syste but it is so satisfactory in the location at our disposal that I doubt t advisability of making any change, at least until a completely new fo of sewage treatment is installed.

SLUDGE DIGESTION AT JOINT DISPOSAL PLANT OF LOS ANGELES COUNTY SANITATION DISTRICTS

By A. Perry Banta*

Sewage treated at the Joint Disposal Plant of the Los Angeles County Sanitation Districts produces, in the presedimentation tanks, an average of 4300 gal. of raw sludge per million gallons of sewage treated, representing 1500 lb. of dry solids. The detention period in the presedimentation tanks is 30 min., during which time 70% of the settleable solids are removed. The sludge has a moisture content averaging 95.7%, and contains on the average, 63% of volatile matter. The sewage is in such condition when it reaches the plant that it is necessary to remove the sludge from the presedimentation tanks promptly in order to prevent gasification and floating. The treatment of this presedimentation sludge is the problem, the solution of which is the subject of this paper.

A review of the technical literature relative to present day tendencies in sludge digestion clearly shows certain developments and practices which are characteristic of successful operation. These are briefly: hydrogen-ion adjustment; optimum temperature regulation; gas collection and burning, or utilization, with resultant odor control; and the circulation or agitation of the digesting sludge. These features, modified to suit the individual and local conditions are now considered essential to efficient digestion.

Experiments were conducted to determine the basic data necessary to make an economic and efficient design for permanent sludge digestion tanks along lines of accepted practice. In general, the questions to be answered were: the percentage reduction in volatile solids necessary to produce a rapid drying sludge without fly or odor nuisance on the drying beds; the time required to dry such sludge; the digestion period necessary; the quality and quantity of gas produced; the optimum proportion of seeding sludge to be used; the relative merits of thermophilic digestion; and the practicability of machine type of digested sludge drying.

It was also recognized that certain materials in sludge digest more rapidly than others, and it appeared that, if a means could be found to segregate or select the more readily digested materials, it would provide a longer digestion period in a given tank capacity for the more resistant materials, or what would amount to the same thing, that it would reduce the capacity required for sludge digestion and at the same time develop more efficient digestion with uniformly better results.

A full-scale digestion experiment, treating the entire production of raw sludge, was conducted in the south tanks of the Joint Disposal Plant. A 5600-gal. redwood tank was also built and operated. A large number of preliminary and check experiments were conducted in the laboratory, using gallon bottles equipped with gas measuring devices. These latter were particularly useful in evaluating variables not readily determined with the full-scale experiments. Small drying beds, 2 by 4 ft. were constructed for drying small batches of sludge.

* Assistant Engineer.

The redwood tank, used as a control, was fitted with heating coils, a gas collecting system, a sludge circulating system, and sampling outlets spaced 5 ft. apart, permitting sampling at various depths. The full-scale experiment made use of clarifiers 5 and 6 and aeration tanks 12 to 16. Tanks 12 and 13 are inter-connected, as are tanks 15 and 16, so that these four tanks were operated as two tanks. Observation in the control tanks indicated that, exclusive of the very lightest and heaviest materials, which were not kept in suspension, the top third of the tank contained 20% more volatile material than the bottom third. It is upon this gravimetric segregation that the theory of multistage selective digestion is based.

The next step was to develop the process on a full-scale experimental basis. Raw sludge and seeding sludge were admitted to clarifier 5. When this tank became full, a portion of its contents was permitted to flow into clarifier 6, the flow being from the bottom of clarifier 5 to the bottom of clarifier 6. When clarifier 6 became full, a portion of its contents was removed from the bottom and pumped into tank 14. When tank 14 became full a portion of its contents, again taken from the bottom, was transferred into tanks 12 and 13. When tanks 12 and 13 became full the sludge from tank 14 was transferred to tanks 15 and 16. When tanks 15 and 16 became nearly full, the contents of tanks 12 and 13 were transferred to the beds for drying.

By this method only the heaviest, less volatile material was progressed toward the final tank, and the lighter, more volatile material was retained in any given stage until, through bacterial decomposition, it was broken down or mineralized into a heavier form. The sludge in all of the tanks was agitated periodically with an air-jet. The stirring effect, from bottom to top, by this method was particularly effective. With this type of stage operation, it was possible to keep the pH above 7.0 by the addition of a small quantity of lime to the first stage. After digestion became well established, it was unnecessary to add any lime to the system. Low seeding ratios have given very satisfactory results, particularly in the control of foaming. A net reduction of 33% in the volatile solids was accomplished and a fast drying, nuisance-free sludge produced.

A paper covering the detailed technical analysis of the data gathered is in the course of preparation and will be submitted to the members of this Association through its own or another publication in the near future. The general conclusions of the study are submitted herewith and are as follows:

1. Multistage selective digestion produces a fast drying sludge of a uniform texture in a digestion period of 25 days or less, without temperature regulation.

2. Further reduction in digestion time may be expected with temperature regulation to 85° F.

3. With multistage digestion it is possible and economical to reduce the ratio of seeding sludge to raw sludge.

4. Multistage digestion facilitates economical and accurate pH control.

5. Well digested sludge, ready for drying, is superior for seeding to semi-digested or aged sludge.

6. Stirring, or circulation from bottom to top in the digestion tank, is a distinct advantage.

7. A reduction of 33% in the volatile solids content of the raw sludge at the Joint Disposal Plant produces a sludge which will dry on beds in about 16 days and which is free from fly and odor nuisance.

8. Machine drying of the vacuum filter type is possible and is one of the most promising fields of investigation.

9. It is more practical to reduce the moisture content of the raw sludge in a super-thickening tank than to decant during digestion.

10. Digestion at 130° F. requires delicate pH control, with added expense for reagent, and produces a sludge with a very penetrating and sickening odor.

11. Digestion at 85° F. produces gas in large excess of requirements for heating.

The districts have under design at this time, sludge digestion tanks of required capacity, capable of ready extension, incorporating principles of design based upon results of the experiments conducted. These tanks will be erected early in 1931 and their departure from present design and operation methods will probably constitute a subject of interest as soon as operation results disclose their merits or otherwise.

HANDLING OF SLUDGE AND SCREENINGS—DISCUSSION

R. F. Goudey discussed preparation of primary sludge and excess activated sludge prior to pumping, then to a gas heated digestion tank, as being tried at the experimental sewage reclamation plant of the Bureau of Water Works & Supply of Los Angeles. In handling excess activated sludge, percentage of water is of first importance. A water content of 99.5% in activated sludge means pumping an excessive amount of water and material that requires heating and aggravates the overflow problem. A decanter tank is used to concentrate sludge, which at times is reduced to one-eighth of its original volume. Fresh and activated sludge are mixed and occasionally lime is added, and the carefully prepared material is pumped to the digestion tanks to avoid undigested sludge staying at the top for a year, as was observed at Pomona. Digestion is obtained in 20 days with production of sufficient gas to heat sludge and produce power to operate the plant. Cooling water in the gas engine driving the generator is used to heat the digestion tank. A tank has been provided to store digested sludge which is drawn daily, equal to the amount of raw sludge pumped to the digester. The stored sludge is held until it is sufficient to fill a sludge bed to a depth of 12 in. It is proposed to install a mechanical filter to dewater the digested sludge and do away with all sludge beds. This method appears to be cheaper in both installation and operation costs and eliminates unsightly sludge drying beds. The only overflow liquor is that due to the difference in moisture content of digested sludge and that of incoming sludge.

M. C. Polk described the separate sludge-digestion plant serving 7000 people at Chico. Sludge temperature is kept at 83° F. by heating with gas collected. Between 2500 and 3000 cu. ft. of the 14,000 cu. ft. per day is burned and the rest wasted. Some trouble at first was experienced with foaming, but now operation is satisfactory. A small incinerator to burn the screenings from the automatic bar screens is soon to be constructed and will use excess gas.

D. C. McMillan described handling of screenings at Ventura which are spread on sand by an ejector to a depth of 6 in. and dried in three days. Odors are kept down with crude carbolic acid. Screenings are used for fertilizer in city park with good results. A home-made centrifugal drier is used during foggy weather.

HANDLING OF SLUDGE AND SCREENINGS AND PRODUCTION OF FERTILIZER AT PASADENA

By A. W. Wyman*

This paper is a brief outline of the 'Handling of Sludge and Screenings' as experienced at the Pasadena treatment plant, and consists of artificial drying of the sludge and, at present, burying the screenings.

A description of the procedure is as follows: activated sludge, having a moisture content of 99.1 to 99.4%, is drawn from the reaeration tanks to one of the two 40,000-gal. conditioning tanks, where it is agitated by compressed air through perforated pipes and a coagulant added of 4.2 lb. of ferric chloride and 4.5 lb. of diatomaceous earth, per 1000 gal. Control gates and floats allow this mixture to feed, as the case requires, one, two, or three, continuous vacuum filters, 11½ ft. dia. by 14 ft. long, where the moisture is reduced to 80%.

This sludge cake coming from the filters in a continuous sheet ¼ in. thick, falls and breaks on a belt conveyor which carries it to the feed end of a double-shell dryer, 70 in. in diam. by 60 ft. long. Natural gas is the fuel used in this dryer and the sludge is subjected to a temperature sufficient to produce practically dry material at the discharge end. Furnace temperature is from 1500° to 2000° F.; discharge end, 500° to 700° F.; and the waste gases have a temperature of 170° F. This material is then elevated by bucket conveyor to a pulverizer, where it is ground to the required fineness and sacked in 100-lb. bags. These bags are tagged with the name 'Nitroganic', analysis guarantee, and 'City of Pasadena', and then stacked ready for sale.

Screenings are the materials rejected by a rotary screen 8 by 8 ft., having slots 1/16 by 2 in. A bucket elevator conveys this to a hopper, under which a truck may be driven and the material taken to ditches prepared in advance and immediately covered. It has been our desire to eliminate the burying of screenings and in a short time an experiment with this in mind will be tried. Burying is very expensive and a few years ago, when filtered sludge was handled that way, involved a cost of $35,000 for one year. Those familiar with the activated sludge process know that the solids in sewage are responsible for a large per cent of the air consumption. To reduce this expense, presedimentation is practiced almost universally, but in our case where a high-grade fertilizer is produced, these screenings should also be reclaimed. At times, due to repairs on screen, sewage has been by-passed to the aeration tanks, and the effect of this procedure after three or four days is a slimy and wet filtered sludge cake, which, of course, limits the capacity of the dryer. This seems to prove under-aeration, or rather, not long enough detention. The quantity of screenings producing this effect is only about 95 cu. ft. per day, having a moisture content of 85% to 90%. This quantity has reduced greatly in the last few years, and now represents 12 or 13 cu. ft. per million gallons.

Our proposed plan is to discharge these screenings into one of the

*Superintendent, Pasadena Sewage Treatment Plant.

aeration tanks, dilute to 99% moisture, and aerate for a period of hours to digest and condition so they may be added to our fertilizer. If this treatment proves successful our recommendation would probably be to eliminate the fine screens entirely and build a short detention, presedimentation tank, and treat the solids from it in this manner. It is hoped that the saving in screen operation, power, and reduced air in plant, due to reduced solids in main process tanks, would more than offset the cost of longer detention for the raw solids, or screenings, in a separate aeration tank. Our present method costs $4200 per year, and includes the items of maintenance, labor, power, trucking, ditching, and covering. The value of the screenings as fertilizer and potential saving would represent a reduction of $2 per million gallons of sewage treated.

Coming back to the subject of sludge handling by the method of artificial drying, we should not forget conservation. Until very recent years, conservation of anything pertaining to sewage (that is, in this country) was seldom talked of, except possibly when some careless person dropped a ring, a watch, or even a billfold, into the toilet, and after getting up courage would inquire over the telephone if the operator at the plant had intercepted such an article. But recently much has been said, and not a little done, toward the conservation of clarified sewage effluent and sludge fertilizer. Engineers who are interested only in cost in dollars may not believe in this kind of conservation, especially of the fertilizer.

Separate sludge digestion may be somewhat cheaper, but why should at least 4% nitrogen and several tons in volume be allowed to go to waste when California land is much in need of them. The net cost of sludge disposal at the Pasadena plant for the fiscal year ending June 30, 1930, was $4.59 per million gallons.

The location of our treatment plant, strict requirements by state and county as to odor and dust control because of close proximity to residential properties, add several dollars per million gallons to the cost of sludge disposal. Milwaukee, for instance, handling an output of over 100 tons daily and with little cost for odor control, is able to produce a similar fertilizer much cheaper than we do. Of course we are not finished yet, and with a larger dryer and equipment almost ready to put in service, we expect to show some interesting results and maybe lower costs. Sludge disposal has been accomplished at Pasadena by reclaiming a high-grade fertilizer, high in nitrogen, free from weed seeds, sterile, and with no boron, worth to the California rancher much more than it costs to produce. Therefore let us go one step further in sewage conservation and save the nitrogen as well as the water.

The following data may be of interest to some:

July 1, 1929, to June 30, 1930

Total sludge filtered	99,346,000	gal.
Total sludge dried	2,879.3	tons
Sludge filtered per ton dried	34,504	gal.
Fertilizer produced per M. G. raw sewage	0.992	tons

Revenue	$63,016
Net Inventory	9,507
Total Revenue and Inventory	$72,523

Cost of Filtering and Drying

Filtering	per M. G.	Per ton fertilizer
Salaries	$ 3.50	$ 3.53
Expenses	12.41	12.51
	$15.91	$16.04
Drying	$ 5.61	$ 5.66
Salaries	8.06	8.12
	$13.67	$13.78
Total filtering and drying	$29.58	$29.82

Fuel costs, drying	$2.40	per ton
Fuel costs, deodorizing	2.94	per ton
Total	$5.34	per ton
Electric power costs, by filtering	$1.48	per ton
Electric power costs, by drying	1.00	per ton
Total	$2.48	per ton

SELLING ACTIVATED SLUDGE FERTILIZER IN CALIFORNIA

By A. F. Thornton*

In 'Nitroganic' we have a new type of fertilizer, yet old as the world itself, and our problems in selling and the breaking down of sales resistance are different than with most other commodities.

The utilization of a waste product of this kind is so foreign to the ideas, and I might almost say, the ideals of the American public that to use it as a plant food is distasteful to many. Sewage has been something that the average community doesn't even like to think about and it will need plenty of publicity of all kinds in other than sanitary or technical magazines to convince the public in general that fertilizer from a sewage plant is a clean product.

The average human visualizes our product in the words of the 'Specialist', by Chick Sales, and immediately a bar of prejudice and sales resistance is raised that is almost too costly to break down for any private concern. Semi-technical articles in our leading magazines and general newspaper publicity by experts, such as yourselves, will go far in educating the great American public in the use of this material.

Lawn Fertilizer—I have been in the fertilizer business for almost twenty years, and I have never seen anything that will give the general satisfactory results on lawns that 'Nitroganic' seems to give; yet our sales to private homes and golf courses are a very small part of our output. As expressed by a friend of mine, chairman of the greens committee of one of our local clubs, "I don't care how good 'Nitroganic' is or how pure, it is human manure, and so long as I am chairman of this greens committee, we will never use it." In answer to my query as to his use of animal manure he said he was used to that.

You would be surprised at the prejudice that exists in the minds of some men of otherwise sound judgment and open minds. When I first took over the sale of 'Nitroganic' I had two salesmen calling on the golf clubs, nurseries, and seed stores. Although at first we had good success, I was finally forced to withdraw entirely from this class of trade, at least soliciting it, for the costs were greater than the returns. It was not due to poor salesmanship nor poor results from the fertilizer that we lost business, but, in my opinion, entirely to the origin of the material. I am frank to say; I don't know what the answer to the problem is, unless it be education of it's use by publicity. I don't want you to gather from this that we are not selling any of the golf clubs or private homes; to the contrary, there are several clubs that buy considerable from us from time to time, and we have numerous outlets that sell private homes, but, we are not getting the business that we should, and that we are entitled to.

*Sales Agent for Pasadena's 'Nitroganic' Fertilizer.

The Citrus Grower—The bulk of all fertilizers is used by the citrus grower in California. The deciduous fruit grower and vineyardist uses very little, although the vegetable grower uses considerable; but the total of the three isn't a drop in the bucket to the hundred thousand tons used in California. The growers of citrus fruits in California bring animal manure and alfalfa from Imperial valley, bean straw from Ventura county, cottonseed meal from Mexico, and blood and tankage from South America, as well as synthetic nitrogenous products from Germany and Norway.

These last named products, the synthetic, more or less set the price of all nitrogen fertilizers, organic and inorganic. The consumer is looking for, and has reason to expect, $2 nitrogen before very long. He almost has it this year, with the price of sulphate of ammonia slightly over $40 per ton. We are getting from $4.50 to $5.00 a unit for our nitrogen, and this price is based on the animal manure price or the value of the product from a feeding angle, its protein value. Organics, in my opinion, will always bring more money than minerals, for the day of the horse has gone, and the cow and sheep are moving farther and farther away, and the cost of delivery is getting more and more expensive, so our only large potential source of organic nitrogen is sewage.

If all the large cities of the Pacific Coast were to suddenly put in sewage treatment plants, the price of sludge would very probably be cut in half, as we would have more than this part of the country could consume; but, with the gradual installation that will take place I see no reason why the price should materially change, except as other commodities of like nature may change. We have had more of an upset condition this year than for a long time, with everybody expecting lower prices and the large producers holding off their price schedule, each one waiting for the other to bring out their price list, and, as a consequence, no one willing to contract ahead. The price of any fertilizer depends, of course, on supply and demand, and the demands depend on returns from crops, and this in turn determines the economically sound amount of money that may be spent on any given crop. The supply would appear to be unlimited from our synthetic sources and the new Guggenheim method of precipitation of nitrate of soda.

The bigger a man is mentally, the quicker he is to acknowledge that he knows nothing about fertilization, though he may have been a user of it for years; and when I find a man who talks learnedly of the soil pH, phosphoric acid, reversion or pounds of actual nitrogen to a tree, the quicker he can tie himself into a knot. Not long ago I stopped in an orange grove to ask a direction from a rather elderly gentleman whom I saw on the lawn. Quite naturally, after he gave me the information, I started to talk fertilizers, and handed him one of my circulars. In the analysis of the nitrogen it gives 'Ammonical Nitrogen Per Cent', he asked what that was, and I said, "I don't know". "Young man," he said, "don't you know you shouldn't sell anything unless you know what it is?" I told him I was sorry but that I had only been in the business twenty years, and didn't know much about it. He shook my hand and said, "Do you know I've been growing oranges for forty-two years, and up to

two years ago I was farm advisor in this district, and I don't know a darn thing about growing oranges yet."

With the citrus grower, who is the greatest commercial user of fertilizers, I find that this material 'Nitroganic', being what it is, breaks down sales resistance, and I am sure of at least an interesting listener. We must, however, meet price competition, and even then, our article, being new to them, they hesitate to use it in considerable quantities. A trial order is the best we can expect the first year. We are over the worst now, as some of the largest growers have been trying the sludge for several years, and are well satisfied.

At what price such material as 'Nitroganic' can be made, I don't know, but there are certain limitations as to what the farmer can pay. I would say that a return of from $20 to $25 a ton could reasonably be expected by any district with a plant making the same sort of fertilizer that the city of Pasadena is making. As the efficacy of this particular organic fertilizer becomes better known, we may even see an improvement in price. One advantage that I can see, of a high-grade material, is that we can afford to distribute at greater distances; in other words, our points of consumption need not be adjacent to points of manufacture. Under the present method of selling 'Nitroganic' it is a specialty, exactly the same sort of a specialty as low-grade tankage or cottonseed meal, and must be made attractive to the buyer from its results in the soil as well as price. I am of the opinion that by the time other material of the same kind is manufactured, the California farmer will be so well educated that there will be no doubt of his ready acceptance of additional amounts. The other method of selling material of this kind would be to manufacturers of mixed fertilizers. It mixes well, and is entirely acceptable to them as a source of organic nitrogen.

What I have attempted to show in this paper is that there is a large sale for such an organic fertilizer as the city of Pasadena is now making, and as time goes on our citrus growers will more and more realize its worth; and if municipalities or sewage districts can afford to make and sell at a reasonable price, they will be doing a vast amount of good to California agriculture.

SELLING SEWAGE SLUDGE AS FERTILIZER

By C. Clay Kellogg*

The following is my experience with sewage sludge as a fertilizer. At the present time I am marketing the sludge of five sewage disposal plants: the Los Angeles County Sanitation District No. 2, which represents 250 dry tons per month; the city of Pomona with 15 dry tons per month; the city of Whittier with 12 dry tons per month; the city of San Bernardino with 30 dry tons per month; and the Orange County Outfall Sewer District with 20 dry tons per month; the total being 327 dry tons, of which 75% is from the first named.

The sludge is sold under the brand name of 'Sludgeon', and is so registered with the State Department of Agriculture of California. The average analysis of all sludge is fairly uniform the year round, it being nitrogen 2%, phosphoric acid 1%, potash 1% and organic matter 40%. This analysis gives you the value of the sludge as compared with other fertilizers, chemically speaking.

The sludge is sold almost entirely in bulk, exclusively to citrus groves. It is delivered and spread in the groves by trucks in the same manner as any ordinary barnyard manure. The moisture content is represented at 30% and should it exceed 30% the net weight is corrected accordingly. I have found it fairly easy to determine the moisture content, through volumetric measurement. It has been my experience that sludge shrinks very little from 45% to 25% moisture. The weight is corrected when it exceeds a calculated weight for 30% moisture which is determined by the volumetric measurement of the truck. For instance, the grower is delivered a load of sludge with the volumetric measurement of 180 cu. ft. The calculated weight, which is based on several analyses for 180 cu. ft. is 4 tons, the moisture content being 30%. Therefore each load delivered to the grower in this particular truck is based on 4 tons, and should the load weigh more, the grower is delivered the actual weight, but is only charged for 4 tons. Should the sludge contain less than 30% moisture, the 180 cu. ft. load would weigh less than 4 tons, in which event the grower is given the benefit.

For an application, I am recommending 4 tons to the acre, twice a year, determined by the size of the trees and the fertilizer program used previously. This application gives the amount of plant food per tree recommended by the University of California and sponsored by the Farm Bureau.

The sludge sells for $6.75 per ton at the plant, and is delivered and spread for $3.00 per ton, making a total cost to the grower of $9.75 per ton at 30% moisture content.

After the sludge has been spread in the orange grove, it is immediately disced under. It is delivered and handled in such a manner that there is no breeding of flies, no offensive odors and it has not proved a nuisance in any respect. I have never had a single complaint from the

* Dealer in fertilizers, Garden Grove, California.

County Health Authorities in whose territory I was making delivery. The growers marvel at the manner in which the sanitary engineer has developed sewage to such a satisfactory marketable condition.

I have ground some sludge and sacked it in 100-lb bags, for use on lawns, shrubs, and flowers, but the amount ground would hardly represent 1% of the output. Growers using the sludge in bulk on their groves often want the sacked sludge to use around the house, and as it gives them the opportunity of a close observation of its fertilizing value I give them a few sacks. In eliminating grinding I can give the grower a greater fertilizer value by handling the sludge in bulk. Besides the added expense, grinding fertilizer is dusty and dirty work, extremely disagreeable to the men employed.

In using sludge on citrus groves, we are getting a higher grade of fruit. We get a larger orange with a better color and a smoother skin. The foliage is a dark green color with a natural growth. The analysis of the soil has shown a marked increase in fertility. Sludge is particularly adapted to sandy soil, and I have never known a fertilizer that would do as well on sand. The growers are gaining a great deal of confidence in sludge and most of my sales are repeat orders. I have cases where the grower has applied sludge to only a part of his grove in which event he has found the results favorable enough to permit the fertilizing of the extire grove.

The sludge has many good qualities and is desirable as a fertilizer because it will not burn, has a long residual value, will not leach readily, has no harmful weed seeds, and no offensive odor.

The results of the sludge fertilization have been observed by the Farm Bureau and by soil experts, and from all indications they are favorable to the sludge as a source of supplying plant food to a citrus grove.

The future of sludge as a fertilizer looks very good.

REMOVAL OF GREASE AND OILS FROM SEWAGE BY THE IMHOFF METHOD

By Wm. A. Allen*

It has long been recognized that the oils and grease wastes which re emptied into the sanitary sewers, whether intentionally or unintentionally, constitute a very annoying problem for the sewage works perator.

At the Pasadena plant, this feature has been given considerable hought since the plant was first placed in operation. Various schemes or the collection of the scum formed were tried in the influent troughs, eration tanks, and clarifier feed-troughs. All of these methods required onsiderable labor for skimming and served only as a cure for the existing ondition instead of eliminating the cause. As early as 1925-6, several xperimental grease traps were constructed in an effort to remove the rease before it reached the aeration tanks. While some removal was ffected, the type of skimming tank did not seem quite practical for large-cale operation.

During the spring meeting of the California Sewage Works Asso-iation in 1929 at Fresno, a general idea of the method used by Karl mhoff was given us by C. G. Hyde. We started construction of an xperimental tank based on the information obtained. This tank was so rranged that it connected as a part of the regular operation instead of eparately as an experimental unit, as we wanted to observe the results nder normal conditions.

The tank as constructed is rectangular in shape, 10 by 32 ft., with n effective depth of 3 ft. Norton porous plates, 1 by 2 by 12 in. are used or aeration. These are arranged in three plate-holders of our own esign, each holder containing 10 plates. They are placed along the all of the flowing-through side. A floating redwood baffle, 4 in. wide y 10 in. deep, with triangular blocks set on top, is used as a retainer or the grease collected. The baffle is approximately along the center ne of the tank. The blocks on top of the baffle are so placed that in ain view a triangular opening is made feeding into the grease collection de, the opening on the flowing-through side being 4 in., tapering to 1 in. n the collection side.

The aeration of the sewage partly emulsifies the oils and greases, that when thrown over in back of the baffle, a light scum is formed hich collects on the surface and is held in the collection compartment the baffle and the cross flow action caused by aeration. The sewage ow from the tank passes under the concrete wall at the discharge end to a concrete flume and then into the influent trough to the aeration nks.

From the start very good results have been obtained on grease moval. As stated, this unit was intended as an experiment. Its use far has more than justified the expense of construction. Within the

ssistant Superintendent, Pasadena Sewage Treatment Plant on p. 53.

next few months the skimming tank will be enlarged to at least double the present size to obtain a greater removal of grease from the sewage. The enlarged unit will have about 3 min. detention, as recommended by Imhoff. The present unit has 1.3 min. detention, which is apparently nearly sufficient to remove the ordinary greases contained in the sewage, but not large enough to care for the excess oils. Since using the skimming tank, there is a noticeable improvement in the amount of grease scum appearing on the surface of the aeration tanks. There are times when unusually large quantities reach the plant with the sewage, and due to lack of capacity, some of the oil passes into the aeration tanks, resulting in incomplete aeration and a lower standard of clarification.

The oils received on these occasions are usually fuel oil, or waste oils from garages and machine shops. The practice of emptying these oils into the sanitary sewer is prohibited by city ordinance, but Saturday night seems an excellent time for someone to disobey the law. By close cooperation with the inspection departments of the contributing cities, instances of this kind are kept down fairly well.

The average removal from the skimming tank is about 20 cu. ft. of scum daily. This scum is removed by hand skimming and dump trucks, and buried in trenches with the screenings from the Dorr screens.

A partial analysis of the scum shows the following:

Oils and fats	24.50%
Loss on evaporation	84.22%
Loss on ignition	13.78%
Ash	2.00%
	100.00%

Anyone familiar with the activated sludge process of treatment can readily appreciate that the removal of this much grease is a decided advantage to aeration and clarification.

Prior to using the grease-skimming tank, it was often necessary to employ an extra crew of 4 to 10 laborers to skim the grease scum off the aeration tanks after a large quantity of oil reached the plant. It usually required several days to accomplish this and the effect was noticeable for several days after.

An estimate of the cost of grease skimming prior to the construction of the skimming tank is $1200 to $1500 per year. Since using the tank, this expense has been eliminated, our own crew being able to care for any skimming to be done.

We now find the grease situation fairly easy to cope with, and after enlarging the grease tank, we expect very little difficulty from grease. It is still contended, however, that the most efficient and economical method of grease removal is at the source. If we can eliminate the cause, no remedy is required. This angle of the situation is, I believe, very important and should receive equally as much attention as how to dispose of the grease and oils after they reach the treatment plant.

LOS ANGELES METHOD OF GREASE REMOVAL

By G. A. Parkes*

The city of Los Angeles disposes of its sewage by dilution into the Pacific Ocean at a point about the middle of Santa Monica bay. The sewage, before being discharged into the ocean, is passed through fine screens of the Dorrco type, which have slots 1/16 by 2 in. Any solid or liquid matter which will pass through these slots goes out to sea without further treatment, while the solid material rejected by the screens is removed and buried.

Some time ago it became apparent that oil and grease which were occurring in increasing quantities in the sewage were causing trouble by blinding the screens, and increasing the cost of maintenance. The oil and grease which did not stick to the screens passed through with the sewage and eventually found their way back to the beach in the vicinity of the outfall and caused objectionable deposits on the sand.

Accordingly studies were undertaken to eliminate these greases and an extensive series of experiments performed. A number of different systems of grease removal were considered, including the Imhoff method, and several series of tests were carried out to determine the relative merits of grease removal before and after screening. Without going into detail, it may be stated that grease removal before screening, proved to be much more effective and that the Imhoff design of grease removal tank did not prove to be as efficient as our own. In all such comparative tests every effort was made to operate the different designs on the same basis, so that results would be truly comparable. All conclusions were based on the results of careful sampling and the analysis of many samples. Several interesting points were noted in connection with this sampling and analysis and it became apparent that the usual methods used were not always applicable.

Naturally a complete description of all the work done during these tests, which lasted in all about a year and a half, would be quite voluminous and no doubt tiresome to one not directly in contact with it, so the present paper will be confined to the design which seemed to give the most satisfactory results and which will probably be used if a full-sized grease-removal plant is to be installed.

In the first place, it should be stated that sedimentation in any form is not at this time contemplated in connection with sewage disposal at Hyperion, so that the grease removal problem was attacked from the angle of flotation only, with the assumption that the heavier solid matters should be carried on into the screening plant to be removed by the fine screens.

It was found that aeration aided greatly in the flotation of the greases and oils and that by proper control a thick tenacious scum could be formed, which could be easily removed from the surface of the sewage. Experiments showed that a tank designed with a relatively flat bottom slope—not over 40 deg. from the horizontal—could be used if

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the retention period in the tank were short enough to prevent the deposition of lighter solids.

The accompanying diagram shows the approximate proportions of the tank design which proved to be most satisfactory during the recently completed experiments, which were made on quantities of sewage as high as 6.67 cu. ft. per sec. The inlet channel at the left is rectangular and of proper size to give a velocity of at least 2.5 ft. per sec. It is in this channel that the aeration is applied by a diffused air system of our own design. The aeration channel flares to the full width of the tank between points B and C, and at C the width of the tank is approximately one-third the length C-D. At the point C the inlet velocity is less than 0.5 ft. per sec. at maximum flow, and decreases rapidly in moving forward into the tank. The air quickly brings the grease and oils to the surface and forms the scum already mentioned, which collects on the surface of the sewage at the left. Here it is removed by a Link-Belt scraper at D and carried to a smaller concentrating tank, not shown. The sewage

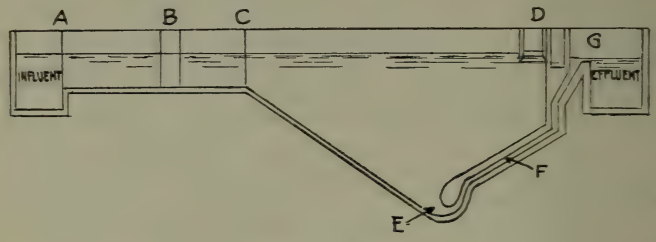


DIAGRAM OF
LOS ANGELES TYPE GREASE SKIMMER

passes downward and out through a carefully formed outlet slot E extending across the tank into the outlet passage F, where a velocity of 3 to 4 ft. per sec. is maintained. The sewage finally leaves the tank over an adjustable weir G which maintains the sewage at an optimum water level.

The method of aeration used consists of discharging small streams of screened sewage at high velocity into the sewage in the aeration channel. These high-pressure nozzles are spaced 2 in. above the surface of the sewage, and in passing through this 2-in. space each fast-moving stream of water carries a large volume of air by surface friction into the sewage body. This system introduces the air into the sewage in very fine form, and while fairly high in cost, is simple in operation and far more effective in removal of grease than any of the types of aeration now in use.

The tank is designed for brief retention periods, from 2 to 3 min being found most satisfactory. Longer periods did not produce increased efficiencies, but did permit the deposition of greater quantities of sludge.

Investigation showed that combined or saponified greases and fatty acids were not objectionable from the standpoints of screen maintenance or beach pollution, but that free or uncombined oils and greases were objectionable from both standpoints. Consequently, all results were

considered on the basis of the removal of free greases and oils, although the available methods of grease analysis probably do not give a true measure of such material present in the sewage and the results probably err on the side of safety.

Removals of 50 to 75% of the free grease were obtained with the design shown, which on a full-size basis would be the equivalent of 4 to 6 tons of pure free grease and oil per day. Such material would not be removed in pure form, but would probably amount to 12,000 or even 20,000 gal. per day of greasy material, removed in the form of scum and containing much water, rubbish, and other floating matter.

The cost of removing grease by this method in a large installation has been roughly estimated at 15 to 30 cents per million gallons, including power and labor but not capital charges. The cost of constructing such a full-size plant has not yet been fully determined.

The grease and oil so removed has little or no commercial value on account of impurities, but may be burned in a properly designed furnace.

The city of Los Angeles is considering the installation of a full-size plant of the above design to treat the entire flow of sewage at Hyperion.

SAN DIEGO COUNTY KEEPS GREASE OUT OF SEWERS

By G. C. Zuckweiler*

I have been asked by President Batty to prepare a treatment paper on my experience with grease traps ahead of sewage plants.

First, I would like to relate my experience with septic tanks, both large and small.

Just after my appointment as chief sanitary inspector for the county of San Diego, I received complaints relative to septic tanks not functioning properly. I was informed that the tanks had to be cleaned too frequently. These complaints all came from food-handling establishments such as restaurants and hotels. These complaints were not a matter of proper disposal of the effluent as in most cases, but simply that the tanks were not functioning properly. A comprehensive survey of these places disclosed that the wastes from the kitchen sinks were discharging into the tanks, carrrying with them a large amount of grease and destroying the bacterial action and causing the tanks to fill such as you would a barrel or bucket if you would fill them with water. I immediately saw the need of grease traps in food-handling establishments. Traps were installed in the sink lines and the condition was remedied.

Section 186 of our County Ordinance No. 323, regulating grease traps reads as follows:

"In cases where a building is used as a hotel or restaurant, the owner or lessee shall provide a properly constructed water cooled or approved grease trap, through which all water containing grease shall be separated before entering the main sewer." This section is strictly enforced in San Diego county.

I also received a complaint from the superintendent of the Edgemore Farm which is the San Diego County Poor Farm at Santee, and found the same condition as at the afore mentioned places. A large three-compartment septic tank had been installed to care for all the sewage, including the wastes from the kitchen sinks and dishwashing machine. This tank was 20 ft. long, 10 ft. wide, and 6 ft. deep, and had to be cleaned about every 4 months, and when cleaned it was found that the first compartment was a solid mass of grease.

This institution had at that time 175 inmates, including employees and several more buildings were under construction to house more inmates.

Since then, I have installed a sewer system and a treatment plant as there are about 400 inmates and employees now at the Farm. This is a small town in itself. This plant consists of a wet pit, pump and motor room, Imhoff tank, dosing chamber, sprinkling bed, sludge bed, settling tank, and a natural sand-filtering bed to care for the effluent when it is not being used for irrigation purposes.

My previous experience with the small septic tanks was proof that grease must be separated from other wastes where practical, before

*Chief Sanitary Inspector, San Diego County.

entering a treatment plant, especially the kitchen wastes that would enter this particular plant. Sink wastes consist of animal fats, such as grease from fat meats, lards, tallow, butter, cream, and many other fats; also soap and many kinds of salad oils are found in kitchen wastes. These are detrimental to the operation of a sewage treatment plant and do not readily respond to bacterial digestion, and when separated from the sewage a more efficient sludge digestion takes place and one can be assured of a better sludge and effluent. Greases also congeal and clog waste-pipes and I felt that the place to eliminate the disposal of the grease was at the point of origin and not at the plant where it would be detrimental and retard the action of sewage digestion.

To accomplish this, it was necessary to disconnect the kitchen fixtures; namely, the kitchen sinks and dishwashing machine, and connect them to a small grease trap which I built in the rear of the kitchen and a larger trap about 150 ft. from the first grease trap. The small trap is 4 ft. long, 2 ft. wide, and 3 ft. deep, with a baffle in the center. The large trap is 6 ft. by 6 ft. and 8 ft. deep. These traps are connected with a 3 in. cast-iron soil line, and cleanouts are installed every 30 ft., so that if the grease while in transit to the large tank should adhere to the pipes, it could be easily cleaned, but as yet we have had no occasion to use the cleanouts. The grease which passes through the small trap is safely deposited in the large grease trap. These traps are cleaned twice a week by the operator of the plant and an average of 75 lb. of grease is taken out at each cleaning. This amounts to 150 lb. of grease a week, 600 lb. a month, or 7200 lb. a year. This is quite a lot of grease to take from one institution, and one can readily see the amount that would go into a treatment plant in a town where there are a considerable number of institutions or food-handling establishments contributing kitchen wastes to a plant.

I find that when drawing off the sludge from the plant that the odors are not as offensive as I have experienced in other sludges, and such odors are indications of a well digested sludge. We are also getting a clear, odorless effluent. In this particular installation it was not difficult to separate the grease from the sewage, and neither would it be in other cases if the proper precautions were taken to prevent damaging wastes from entering the sewer and reaching the plant. Establishments which contribute wastes that are likely to be troublesome in the treatment of sewage can be regulated by ordinances.

LOS ANGELES SUCCESSFULLY RECLAIMS SEWAGE FOR REPLENISHMENT OF UNDERGROUND WATER SUPPLY*

By Carl Wilson

Director of Sanitation, Los Angeles Department of Water and Power.

Because all the water which naturally belongs to semi-arid Southern California, together with the supply which has been imported from other basins, and that which is still available for importation, will not suffice for the ultimate needs of this rapidly developing area, it is necessary that intensive conservation of all waters be immediately inaugurated. In a general way, conservation in industry has meant the transformation of wastes into by-products, and the industry of purveying water is not an exception to this rule.

The first by-product which the water works engineer turned to advantage was hydroelectric power, but there remains a waste from his enterprise which has thus far been neglected, even though its disposal has cost in the aggregate untold millions of dollars. This burdensome waste is sewage, and its principal by-product is reclaimed water which may be given many useful applications. Realization of the impending need caused the officials of the Department of Water and Power of the City of Los Angeles several years ago to undertake an investigation of the possibilities. It was realized from the outset that successful reclamation, if used to replenish underground storage, either directly or through return water from irrigation, offered the possibility of serious consequences. One part of phenol in 500 million parts of water may cause annoying taste troubles, while half that amount of salicyl compounds may be even worse. Because of the complicated reactions which might be anticipated, and also because the earlier studies were so promising, it was decided late in 1929 to place the investigation upon an experimental basis so that authoritative data applicable to Southern California conditions might be made available. The program adopted is ambitious, but to have made it less comprehensive would have been to defeat the purpose.

Any scheme of sewage reclamation must necessarily begin with sewage reduction, a subject around which there has been developed a voluminous literature during recent years, but valuable as this fund of information is, it stops far short of the present goal. It concerns itself with sewage disposal, and carries treatment only to the minimum degree which will insure freedom from nuisance.

Our problem in Southern California compels us to make sewage treatment a special business, for we must produce an effluent which is useful and attractive, although we can easily conceive that here, as in other industries, we may turn out products of various grades implying different costs and different selling values, which shall be applicable for different uses. At present, the activated sludge process is in the ascendency, perhaps because it is based upon the utilization of natural forces, which are accelerated and controlled by scientific adaptation of environment to secure the most efficient operation

*Reprinted from Western Construction News, issue of September 25, 1930.

iological process. Therefore, it was decided to construct an activated ludge plant to treat 200,000 g.p.d., and this plant has been in uninterupted service since May 12, 1930. It is situated on the edge of Griffith ark, upon property belonging to the Department of Water and Power, djacent to a playground camp, the municipal golf course, and close to a vell-travelled highway, so that no odor nuisance can be tolerated.

Sharp criticism from some quarters has been directed at the activated ludge process as being unable to handle industrial wastes, but it is elieved by those conducting the present experiments that careful attenion to the fundamentals underlying the process will secure success with ll types of organic wastes. We are utilizing the activities of bacteria,

eneral View of Sewage Reclamation Plant. Aeration Tanks in Center with Clarifiers and Digesters at Rear, Filtration Works at Left, and Sludge Beds at Right.

ngi, and protozoans, and we know they are very sensitive to acids and lkalies—therefore we must carefully control the hydrogen-ion concenation (or pH) in our plant. They function best at their optimum mperature, hence we must preserve temperatures within certain limits. Ve know that up to a certain point in our process, aerobic action is referable to anaerobic reduction, although this condition is reversed in ie case of separate sludge digestion, especially if gas collection is a part f the scheme. Therefore, we must constantly provide air to inhibit naerobic action and promote aerobic processes in the aerators and larifiers. Lastly, we know that certain inorganic salts interfere with ie treatment.

Inorganic salts in excess of certain concentrations, must therefore e kept out of the sewers, and that seems an entirely feasible thing to ccomplish. By satisfying these conditions, it is practicable to treat all rganic wastes, and peach cannery wastes have already been successfully eated at the experimental plant.

An important feature of the study now being conducted is a deterination of the maximum concentration of certain inorganic compounds, uch as salt and alkalis, which may be permitted in industrial wastes hich are allowed to enter the sewers. Of equal moment is an investigaon of the degree of purification necessary in effluents destined for ifferent purposes. Reclaimed water intended for irrigation need not e so highly purified (consequently the cost may be less) as for some her use. Therefore, a correlation between treatment costs and proposed ses is of great importance.

The complete program of the Department's reclamation studies is published herewith to show the extent of the enterprise, and also in the hope that it may save some unnecessary duplication of effort, with its accompanying expense.

A completely equipped laboratory has been provided at Crystal Springs for the exclusive study of sewage treatment and its allied problems, including the feasibility of introducing sewage effluents into the groundwater by infiltration through the sand and gravel deposits overlying or tributary to the underground basins.

The work thus far accomplished sounds a warning which seems unavoidable—that if disaster is to be averted, the disposition of sewage effluents where they may reach waters used for domestic supply, must be under the control of the authorities responsible for the quality and safety of the water. The potential possibility of seriously affecting present and future supplies destined for human consumption is such that constant control of the quality of the effluent must be exercised, and the effect of the effluent upon underground waters must be continuously studied if the quality of our domestic supplies is not to be jeopardized. It would seem that only those officials who are held responsible for the safety and quality of public water supplies are likely to appreciate the importance of such studies, or the many conditions which must be guarded against. Moreover, the technology of water quality has become so complex that only the water works laboratories are likely to be equipped for the conduct of the necessary control, or to adequately interpret the laboratory findings.

PROGRAM OF WATER RECLAMATION STUDIES

The following outline covers items under investigation on the subject of 'Reclamation':

1. Volume of municipal waste water available.

(a) Location of all sewers, 24 in. diam. and larger.
(b) Average, maximum, and minimum daily and seasonal flows both for the present and the future, determined at the principal gathering points of intercepting sewers.
(c) Elevations at which adequate volumes can be secured.
(d) Possible rerouting of existing or proposed intercepting sewers to favor the various projects under consideration.

2. Character of waste waters.

(a) Strength of waste waters at different points.
(b) Checking mineral contents from each intercepting sewer and if any exceed working limits, continue studies to either find means of control or separate disposition.
(c) Study of industrial loads for different areas.
(d) Effect of future industrial loads on character of combined wastes.
(e) Selection of those intercepting sewers which, from the standpoint of the character of their wastes, the best combination for each scheme under consideration is obtained.

3. Treatment of municipal waste waters.

(a) Complete knowledge on the most up-to-date developments in sewage treatment, including that for industrial wastes.

(b) Research into the proper methods of treatment as adapted to our type of sewage and climatic influences.
(c) Determination of installation and operation costs for that degree of treatment required by each project under consideration and industrial wastes to be handled.
(d) Selection of suitable treatment plant sites or pumping plants and force mains to known sites best fitting in with each project.
(e) Cost of sewage works to ocean versus reclamation.
(f) Cost of additional treatment required at the ocean end, which may be avoided if some scheme of reclamation is adopted.
(g) Determination of what part of the additional treatment required for reclamation is chargeable to sewage disposal.
(h) Analysis of so-called aesthetic and social objections.

Types of reclamation under consideration and research involved.

(a) Augmentation of domestic supplies.
(1) Addition to large reservoirs in times of extreme emergency involving studies on the sufficiency of complete treatment and the effect on the biological balance in the reservoirs.
(2) Replenishment of underground water supplies above wells and galleries involving studies as to where this can best be accomplished; experiments in spreading of such waters in galleries or on the surface; percolation experiments; purification effected by filtration resultant from spreading; travel of underground pollution; study of chemical transformations during its period of underground travel; and the percentage recoverable in different basins.
(b) Exchange with large irrigation companies using their water for domestic purposes.
(c) Sale to irrigation companies in Los Angeles and other counties, involving: study as to location of such companies; acres under cultivation; types of crops grown; what safe return value could be secured from the water; extent to which their systems might have to be modified to ensure safe drinking water for them; and, the cost of transportation, storage, and distribution costs.
(d) Development of new acreage in Los Angeles and other counties and the determination of treatment necessary for such projects.
(e) Irrigation of golf courses, large estates, parks, etc., involving studies of location, acreage, and water duty.
(f) Industrial and commercial use of reclaimed water involving study of present and future requirements of such industries that might be able to use reclaimed water.

Resources available in reclamation.

(a) Value of water for domestic use both direct and indirect.
(b) Value of water for irrigation of various crops or purposes.
(c) Value and demand of water for industrial use.
(d) Value of reclaimed water in underground reservoirs in stopping inroads of salt water from the ocean, lowering pumping costs because of the higher water table, and guaranteeing water for valuable crops.
(e) Value of gas reclaimed from treatment works or sold to consumers.

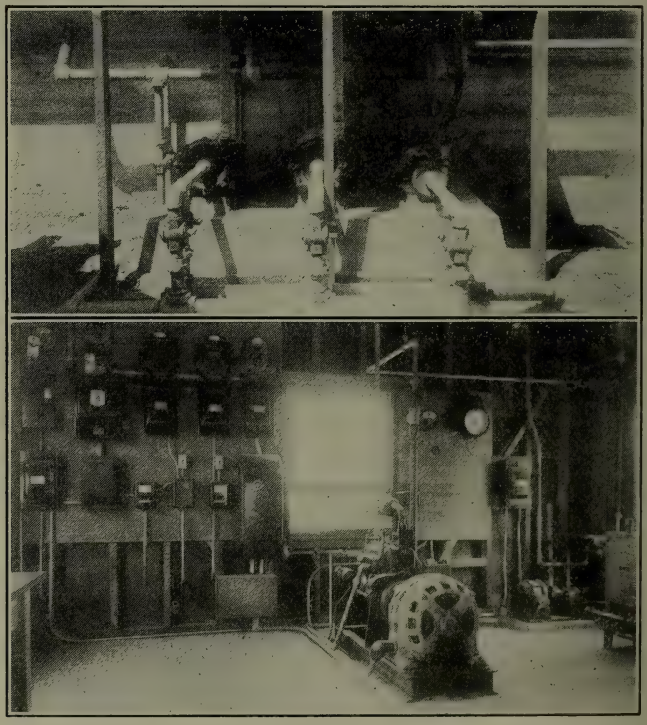
(f) Value of fertilizer in sludge from the treatment works and in th water used for irrigation.
(g) Efficiency of various projects comparing production costs wit reclaimed values.
(h) Comparison of reclaimed costs with existing and future aqueduc supplies.

6. Cooperation with agencies outside the City of Los Angeles.

(a) Collection of sewage from other districts.
(b) Utilization of flood control spreading and storage works i practical.
(c) Joint use of private pipe-lines, storage, or distribution works.

7. Definite recommendations.

(a) Reduction of all projects to a comparable basis, including firs cost, labor, power, chemicals, depreciation, and maintenance fo additional treatment works over that needed for present disposa pumping plants, pipe-lines, storage reservoirs, and distributio facilities.
(b) Whether reclamation is warranted.
(c) What constitutes the most efficient method of reclamation, wh should do it, and how it should be financed.



(Upper) Battery of Sludge Pumps, Showing Suction and Discharge Manifolds. (Lowe Electric Panel and Meters for All Uses. Gas-Electric Generator in Center, Hot Water System on Right, Digester Temperature Recorder in Upper Right.

SEWAGE RECLAMATION PLANT FOR LOS ANGELES*

Bureau of Water Works and Supply Designs and Constructs 200,000-g.p.d. Activated Sludge Plant Employing Separate Sludge Digestion, with One-Third of Final Effluent Carried Through Complete Treatment—Extensive Study of Sewage Reclamation Brings New and Important Discoveries—Construction and Operation Costs Obtained.

By R. F. GOUDEY
Sanitary Engineer, Department of Water and Power,
Los Angeles, California

In its comprehensive program of studying sewage reclamation, the Bureau of Water Works and Supply of the City of Los Angeles, through the direction of H. A. Van Norman, general manager and chief engineer, and Carl Wilson, director of sanitation, and myself has designed, constructed, and placed in operation a complete sewage treatment plant of 200,000 g.p.d. capacity. The plant has been in continuous operation since May 12, 1930.

This treatment works is the first large-scale, complete demonstration plant ever constructed on the Pacific coast and is fully designed and equipped for a thorough and exhaustive research into the art of sewage treatment. In addition to demonstrating accepted methods of treatment, it is planned to investigate new angles of the science and to continue the treatment further than has ever been attempted elsewhere.

A new and fully equipped sanitary chemical laboratory has been built, and already the schedule of tests requires a greater number of sanitary chemical analyses than are handled by combined laboratories of the state.

Purpose of Plant—The ambitious purpose of this experimental plant virtually covers all phases of sewage treatment. For instance, it includes:

Development of a scheme of treatment which will not be a nuisance nor produce any odors, and will advance utilitarian values to a maximum.

Embodiment into one plant of all the best ideas as obtained from visiting other plants throughout the country and gleaned from accounts in the literature of foreign plants.

Utilization of mechanical equipment to the fullest possible extent.

Investigation into the treatment of industrial wastes.

Determination of basic design data for known processes of treatment adapted to local conditions of climate, degree of treatment required, and character of sewage to be treated.

Demonstration of the degree of treatment required for each proposed scheme of reclamation.

Selection of a compact design consistent with simplifying operation.

*Reprinted from Western Construction News, issue of October 25, 1930.

8. Investigation of any harmful constituents in sewage which might interfere with various schemes of reclamation.

9. Reduction of operation costs to a safe minimum, with installation costs kept within reason.

10. Determination of installation and operation costs applicable to large plants, including labor, power, chemicals, depreciation, research, maintenance, miscellaneous items, and contingency.

11. Studies on the recovery of power from gas, fertilizer from digested sludge, and the value of nitrogen in the activated sludge effluent.

12. Construction of a plant such that inspection by the public would gain their confidence and support.

Location of Plant—The treatment plant is situated in Griffith park on the west bank of the Los Angeles river, opposite Burbank. It is at the outlet of San Fernando valley at elev. 475 ft. above sea level. The plant is adjacent to one of the pumping stations of the Water Department and is well isolated. This site was selected after studying many other locations as the one best fitting in with the general plan.

The site is at one of the many favorable locations for future plants of large capacity. It intercepts the San Fernando valley trunk sewer, which is 48 in. diam. and designed to carry a maximum flow of 60 c.f.s., the present discharge being 1,000,000 g.p.d. Over 85% of the sewage of the city of Glendale can be pumped to this site with a 35 ft. lift.

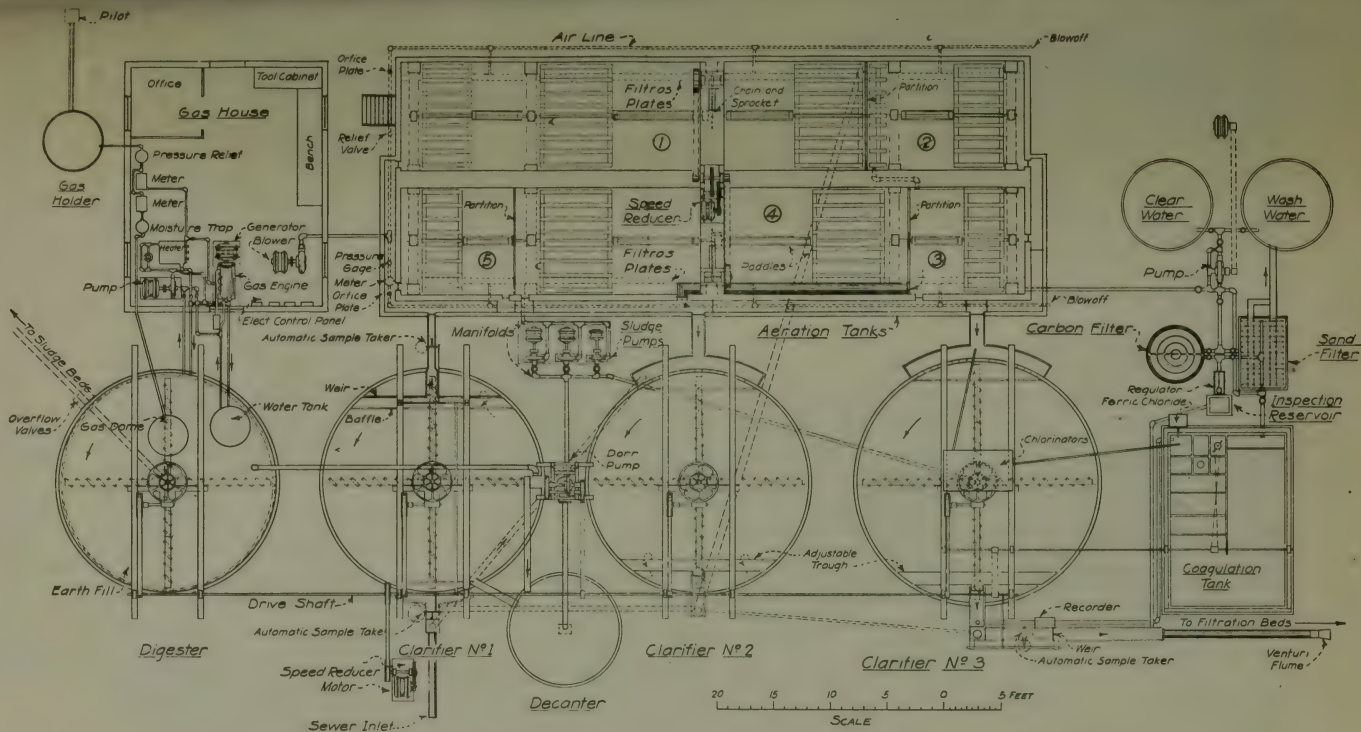
The sewage from this outfall is septic and is subject to severe seasonal loads of peach, tomato, and vegetable cannery wastes in addition to receiving the discharge from pickling works, film laboratories, and a large soap factory.

By constructing an intercepting line 800 ft. up the trunk sewer, it was possible to provide a gravity flow to the treatment plant, built for the most part 6 ft. above ground level, which not only did away with the trouble of pumping sewage to the plant but reduced the cost of installation.

The final reason for selecting the site in question was to spread the effluent on natural sand beds adjacent to the river and at a point 1½ miles above one of the main infiltration galleries feeding the city. Fourteen wells driven on the site fitted in with a large number of similar test wells maintained by the Department in studying the underground flow from San Fernando valley.

Design of Plant—The plant is essentially an activated sludge plant employing separate sludge digestion with one-third of the final effluent carried through complete treatment including coagulation, superchlorination, sedimentation, sand filtration, and dechlorination with activated carbon.

In the first place, the plant is designed to operate along standard lines, but with far more conservative factors than ordinarily used. The layout is such that variations can be made in settling periods, aeration and reaeration detentions, air and power requirements, and all other factors subject to regulation.



Sewage Reclamation Plant For Los Angeles Bureau of Water Works and Supply.

These same units, moreover, are made flexible enough to test schemes of treatment radically divergent from standard practice, and also more complete from the standpoint of producing a more acceptable effluent. All degrees of treatment from settled sewage to drinking water are produced.

Everything subject to measurement is fully metered, such as: sewage flow, gas production, gas utilization, power produced, air consumption, aeration power, sludge pumps, clarifier motors, and wash water pump operation. Composite samples are collected continuously by automatic sampling devices which take samples approximately proportional to the sewage flow.

Operation has been simplified, enabling the operator to keep a complete record of every item entering into a full interpretation of the plant performance.

Description of Plant—The plant consists of the following units: Intake works; sedimentation, with or without coagulants; aeration and final sedimentation; coagulation, filtration and superchlorination works; spreading beds for the final effluent; and sludge conditioning, digestion, filtration, drying, and power development.

Intake Works—The intake is a vertical diversion in a 48-in. sewer 9 ft. below the surface, which normally diverts one-quarter to one-third of the entire flow to the plant by gravity.

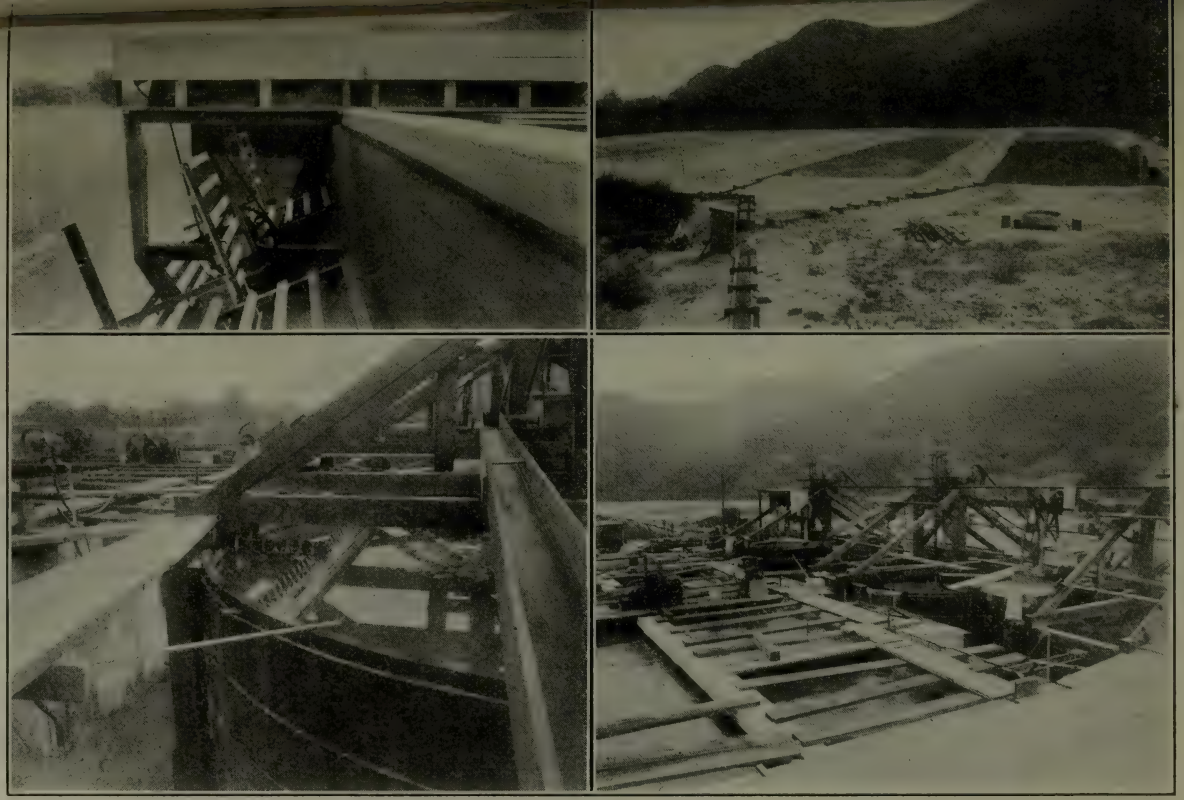
The minimum flow reaches the plant at 8 a. m., the peak flow arrives from 11 a. m. to 3 p. m., and the average flow holds until midnight.

During August, the suspended solids in the raw sewage varied from 272 to 1570 and averaged 530 p.p.m. The oxygen demand value (5-day) averaged 680 p.p.m. It is evident that strong sewage, and what might be considered by some as difficult to treat, is being received by this plant. Even when the canneries are not in operation, the suspended solids and oxygen demand values are higher than the sewage at Hyperion, which is the ocean end of the Los Angeles outfall.

Sedimentation Works—The sewage can be settled once or twice and coagulants can be applied between the two clarifiers used for this purpose. These clarifiers are 20 ft. diam. and 7 ft. deep. They are equipped with Dorr mechanisms. Each provides a 2-hour detention for the average flow, with an overflow rate of 635 gal. per square foot per day. Clarifier No. 1 alone is used in standard treatment for preliminary clarification.

It has been definitely proven by others that 50% removal of suspended solids by sedimentation gives better aeration efficiency than 10% removal by screens. It then follows that greater removals than 50% are desirable. Already this is proving out, and it is proposed to use chemical precipitation to secure the highest possible removals. The sewage in this case will be settled in clarifier No. 2 and ferric chloride will be applied before sedimentation in clarifier No. 1. The latter clarifier will be equipped with sludge recirculation.

During periods when the suspended solids in the sewer ran high, it was noticed that poor sedimentation was secured even with overflow rates as low as 500 gal. per square foot per day—whole peaches and tomatoes



(Upper Left) Imhoff Paddles in Aeration Tank, Filtros Plates Installed in 5-in. Channel at Left of Horizontal Shaft. (Upper Right) Final Sand Beds. Float Recorder on Right for First Bed. Evaporating Pan at Right, Parshall Flume in Foreground, Test Wells on Alternate Dikes. (Lower Left) Cipolletti Weir Outlet System for First Clarifier; Speed Reducer on Aeration Tanks. (Lower Right) Aeration Tanks and Final Clarifiers, W & T Chlorinators on Top Center Clarifier; Dorr Sludge Pump at Left, Automatic Sampler in Trough to Right of Hydrant.

passed through the clarifier. The pH dropped to as low as 6.4 day after day. It was obvious that the carbon dioxide caused a buoyancy which defeated sedimentation to a considerable extent. This was entirely overcome by feeding a small amount of lime into the raw sewage to absorb the carbon dioxide. It raised the pH to 6.8 and good sedimentation seemed to be restored at 6.7 and above. The correction of the pH value to secure good sedimentation and prevent bulking is one of the tricks already discovered by us in the successful treatment of peach and tomato cannery wastes.

The Dorr mechanisms are kept in continual operation and sludge is removed twice daily. The constant squeegeeing of the sludge thickens it far more than results from intermittent operation. The sewage enters the tank at the surface but drops down behind a baffle extending 3.5 ft from the top. The outlet consists of a series of small Cipolletti weirs 2 in wide and spaced 6 in. on centers. Scum is floated off into the decanter tank.

The preliminary clarifier, because of the strength of sewage, use of low overflow rates, efficient inlet and outlet details, and control of pH in the raw sewage, gives exceptionally high removal of suspended solids averaging 82%, with daily variations from 69 to 91%; the oxygen demand value is reduced 60%.

Aeration and Sedimentation—The aeration tanks, two in number, are 55 ft. long, 10 ft. wide, and 10 ft. deep with a semi-circular bottom. The tanks are equipped with Imhoff paddles which revolve at 6.5 r.p.m. against air admitted from a single row of 'filtros' plates 5 in. wide set 1.5 ft. from the side of the tanks and 9 ft. below the top. The amount of air added varies from 0.2 to 0.4 cu. ft. per gal. of sewage treated.

The tanks are subdivided into compartments for use in various combinations. In standard treatment, 6 hours aeration is secured in tanks 1, 2, 3, and 4 and 4 hours reaeration is obtained in tank 5. For cannery wastes, aeration is secured in 5, 1, 2, and 3, with reaeration in tank 4. In multi-stage treatment, primary aeration will be secured in tank 5, sedimentation in clarifier 2, reaeration in tank 4, secondary aeration in tank 2, final clarification in clarifier 3, and reaeration of secondary sludge in tank 3. The principle in this scheme is to first aerate the sewage with a large volume of well-aerated sludge for a short period, and to provide a second aeration with a small volume of sludge but for a longer period. In this case, tank No. 1 will not be in use and this measures the extent of the saving which follows if the process proves successful.

A number of minor experiments are being conducted on aeration. The best measure for the efficiency of aeration appears to be the use of the free ammonia test. By taking these tests in the different tanks, a good measure of the rate of purification is obtained. The major portion of the work is done in the first half-hour of aeration. This shows conclusively the fallacy of adding all of the sludge to the raw sewage with continuous aeration for six hours. There is ample reason on this score alone to advocate multi-stage treatment. But, another scheme was suggested through accident. One of the gates leaked and led to the discovery that if the sludge is fed at different points, still better aeration efficiency

ecured and far better sedimentation is obtained. This is being followed p. Other experiments involve studies of bulked sludge, return of arious percentages of sludge, manipulation of sludge by chlorine, lime, cid, and ferric chloride to alter the percentage volume of sludge in the eration tanks, correlation of air used to oxygen demand reduction, orsepower requirements, and maximum production of nitrates in the ffluent.

Sludge is returned for reaeration by a series of pumps, 15, 60, and 0 g.p.m. which are so connected by manifold suctions and manifold ischarges that all variations in volume of sludge to be returned from ny clarifier and pumped to any tank for separate or combined reaeration an be obtained. Although it is still customary to provide pumps to return 5 to 20% sludge by volume, as found in the aeration tanks, this method not based on actual operating conditions. The pump capacities should e made large enough to keep sludge levels at operating heights in the arifiers covering all variations likely to occur in percentage of water ontent of sludge.

Two clarifiers, one 20 ft. and one 22 ft. diam., give rates of sedimentation from 550 to 1060 gal. per square foot per day, depending on the mount of sludge carried. The use of two clarifiers in series for standard eatment may sound radical to most engineers, but the performance of moving one-half of the suspended solids and oxygen demand value with sacrifice of nitrates or dissolved oxygen speaks for itself. The second arifier acts as a chlorination detention basin and also as a safety valve tercepting any sludge which, on account of a disturbed condition in the evious clarifier, might otherwise escape.

Special experiments in final sedimentation include upward filtration rough sludge, preferably in a semi-bulked state, and perfection of inlet d outlet details. The filling up of the channels of the scraper arms in arifier No. 3 to shed depositing sludge entirely overcomes the periodic ing which gives a bad impression and is noted in all clarifiers.

Chlorine from Wallace & Tiernan chlorinators applied at a rate of lb. per million gallons carries through the clarifier, giving 0.2 p.p.m. the outlet. This chlorine prevents algae growths in troughs and annels and disposal beds. Where formerly without chlorination, algae ubles were caused by discharging the final effluent into sand beds for a ek, continuous runs with chlorination have been extended to 90 days.

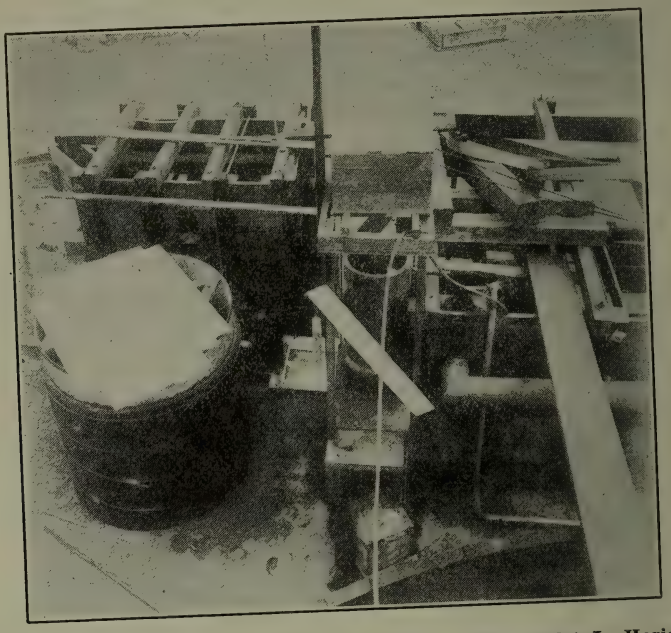
During August, the final effluent from the clarifiers contained .p.m. of suspended solids, 7.5 p.p.m. oxygen demand, and a turbidity 5 p.p.m. At times, the last clarifier was so clear that the brass squeegee tes in the center cone at the bottom of the clarifier could be seen from top of the tank.

Filtration of Final Effluent—One-third of the activated sludge uent is carried on to further treatment of coagulation with ferric oride, mixture with returned ferric chloride sludge, superchlorination, imentation, filtration through sand, and dechlorination with activated on.

The design of the coagulation and sand filtration works departs cally from standard design and is based on original experiments conted by Carl Wilson at San Pedro.

Ferric chloride is added by a machine invented by Wilson. This device can be regulated to feed any desired dose proportional to the flow. Sludge returned from the first-third of the settling tank is mixed at the same point where the new ferric chloride is added. A heavy floc forms at once and the mixture is violently agitated. As mixing becomes gentler toward the end of the mixing period, a large floc forms which immediately deposits in the settling tank. The settling tank is designed for one-hour detention and filter runs are normal, indicating the vast superiority of ferric chloride as a coagulant over alum.

The sand filter can be operated at rates of 2 to 5 gal. per square foot per minute. The sand has an effective size of 0.9 m.m., the sand depth



Filtration Works at Los Angeles Sewage Reclamation Plant. Inlet Is Horizontal Pipe Entering from Right; Ferric Chloride Machine Mounted Above Inlet to Mixing Tank. Small Vertical Pipe Is Sludge Return Line. Square Tank Is Sand Filter and Round Tank Activated Carbon Filter. Final Product—Sparkling Clear Drinking Water in Tile Box in Center.

is 12 in., and the gravel depth is 18 in. Water is admitted to the surface of the sand through nozzles in a surface manifold which keeps the surface sand in agitation. The filter is backwashed, first by admitting water through the surface grid used for the influent and, after the surface is violently washed, the usual backwash from the underdrains at a rate of 24 to 36 in. vertical rise per minute is applied. Wash water troughs are set 10 in. above the sand level. All wash water is returned to the aeration tanks and its sludge eventually reaches the digester. In this manner, no solids pass through the entire process and the total removal is practically 100%.

Chlorine applied at the mixing tank amounting to 25 lb. per million gallons oxidizes any essential oils, tastes, and organic matter, and can

through the sand filter with a residual chlorine value of 0.4 to 0.8 p.p.m. The total contact period in the clarifier and settling tank gives a contact period of three hours with free chlorine during the entire period, never falling below 0.2 p.p.m.

The carbon filter is constructed with the same area as the sand filter and is provided with an upward flow through a 24-in. depth. The carbon filter is ventilated and equipped to be rejuvenated by steam.

In addition to the customary experiments with amounts of coagulant, details of mixing, sedimentation, backwash rates and length of filter runs, particular attention is being given to a study of activated carbon filtration. In the first place, the experiments include several types of activated carbon, although to date only hydro-darco has been used. The maintaining of the surface portions of the activated carbon sterile is a problem. The length of filter runs and the proper method of rejuvenation must be carefully determined. So far, the carbon filter has operated 8 hours daily since May 12 this year, with complete removal of chlorine applied.

The final effluent is sparkling, clear, tasteless, odorless, and free of suspended solids, color and turbidity. It has an oxygen demand value of but a trace and an oxygen consumed value of 2.5 p.p.m.

Spreading Grounds—Five spreading beds giving a theoretical filtration rate of 200,000 gal. per acre per day were constructed by removing the top 15 in. of soil as found at the treatment plant site. The top soil is a fine sandy silt, underlain by coarser sand which merges into sand and gravel deposits of considerable depth. The ground water stands 15 to 35 ft. from the surface, depending upon the season.

The beds have been carefully leveled and the wetted area determined. Each bed is equipped with a gauge. One bed is equipped with a recording gauge and is used for long periods of dosing; its rate of effective filtration, including time out, is 1,000,000 gal. per acre per day. Evaporation is determined by a standard type of evaporation pan.

Fourteen 2-in. test wells have been sunk in and around these beds for the purpose of measuring water levels and collection of samples to determine underground chemical transformation as the effluent moves away, and to study nitrogen changes and travel of underground pollution. The effect of the effluent spread on these sand beds will be carefully studied with reference to infiltration galleries 1½ miles below.

Sludge Disposal—Disposal of sludge has been for many years the bane of sewage disposal, and its mastery now makes for the success of reclamation. This has been accomplished at our plant by improving the separate sludge digestion process and experimenting with the treatment of overflow liquor and filtration of digested sludge.

The sludge works consist of a decanter tank, 10 ft. diam., a covered and heated digestion tank 20 ft. diam. and 16 ft. deep, gas collection, gas utilization through a heater and in a gas-driven electric generator, overflow arrangements, sludge filters, and drying beds.

The sludge process as now developed is odorless because all gases are collected and either burned or put to beneficial use. The reduction of the sludge to a desirable fertilizer is inoffensive, economical, and sanitarian. The success already obtained by this experimental plant along this line has been largely secured through attention to details.

DAY	AIR (INCHES MERCURY)	FILTER SAND HEAD (IN)	CARBON FILTER TIME ON	CARBON FILTER TIME OFF	GAS PRODUCTION CU FT PER DAY TOTAL	GAS PRODUCTION CU FT PER DAY HEATER	GAS PRODUCTION CU FT PER DAY ENGINE	FRESH SLUDGE TO DECANTOR OFF	FRESH SLUDGE TO DECANTOR (INCHES)	FRESH SLUDGE TO DIGESTION (INCHES)	EXCESS ACTIVATED SLUDGE FEET TO DECANTOR	EXCESS ACTIVATED SLUDGE IN TO DIGESTION	% SLUDGE AERATION	% SLUDGE RE AERATION OUT LET	% SLUDGE RE AERATION IN LET	% SLUDGE RE AERATION OUT LET	CHEMICALS LIME WHERE ADDED	CHEMICALS LIME LBS.	CHEMICALS FERRIC CHLORIDE SEWAGE GT	CHEMICALS FERRIC CHLORIDE FILTER GT	CHEMICALS CHLORINE EFFLUENT LB/DAY	CHEMICALS CHLORINE FILTER LB/DAY	HOT WATER WATER	HOT WATER TEMPERATURES DAILY MAX	HOT WATER TEMPERATURES DAILY MIN	TEMP EFF	SLUDGE PUMPS G P M 1	SLUDGE PUMPS G P M 2	SLUDGE PUMPS G P M 3	TESTS PH SETTLED SEWAGE	TESTS PH FINAL EFF	TESTS PH DIGESTED SLUDGE	TESTS FREE CHLORINE FINAL EFF	TESTS FREE CHLORINE FILTER	APPEARANCE EFF	APPEARANCE SLUDGE	VISITORS	LOADS OF SLUDGE HAULED			REMARKS

DAILY LOG

DAY OF MONTH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
AERATION TANKS IN USE																															
REAERATION TANKS IN USE																															
CLARIFIERS FOR RAW SEWAGE																															
CLARIFIERS FOR CHEMICALLY SETTLED SEWAGE																															
CLARIFIERS FOR ACTIVATED SLUDGE																															
SLUDGE PUMPS																															
NO 1 TO																															
NO 2 TO																															
NO 3 TO																															
SCHEME OF TREATMENT																															
EFF. TO BED NO																															
HOURS FILTER RUN																															
HOURS CARBON FILTER OPERATED																															
DIGESTOR OUT																															
GAS OUT																															

SCHEMATIC

SCHEMES OF TREATMENT

1-STANDARD
2-TWO STAGES
3-1 WITH PRELIMINARY CHEMICAL TREATMENT
4-2 WITH PRELIMINARY CHEMICAL TREATMENT

MONTHLY NOTES

DAY	POWER PADDLERS	POWER PUMPS	POWER CLARIFIERS	PADDLES R P M NO	PADDLES R P M 30		
FIRST							
LAST							
TOTAL							

DIGESTED SLUDGE					
WET			DRY		
DAY RELEASED	DEPTH	BED NO.	DAY REMOVED	DEPTH	BED NO.

9-8-1930

Operation Record for Headworks of Sewage Reclamation Plant.

In the first place, only thick and properly conditioned sludge is pumped to the digester. The excess activated sludge is dewatered in the decanter tank to less than 20% of its original volume; experiments may reduce this still further. The concentrated activated sludge is then mixed with fresh sludge. When necessary, lime is also added to the decanter to correct the pH value in the digester. By circulating the combined mixture of activated sludge, fresh sludge, and lime from the decanter through the pump and back into the decanter, the activated sludge when put into the digester will not float and will readily yield to digestion. This process produces a minimum of overflow liquor, saves heat in the digester, and enables the pH of the digester to be easily controlled.

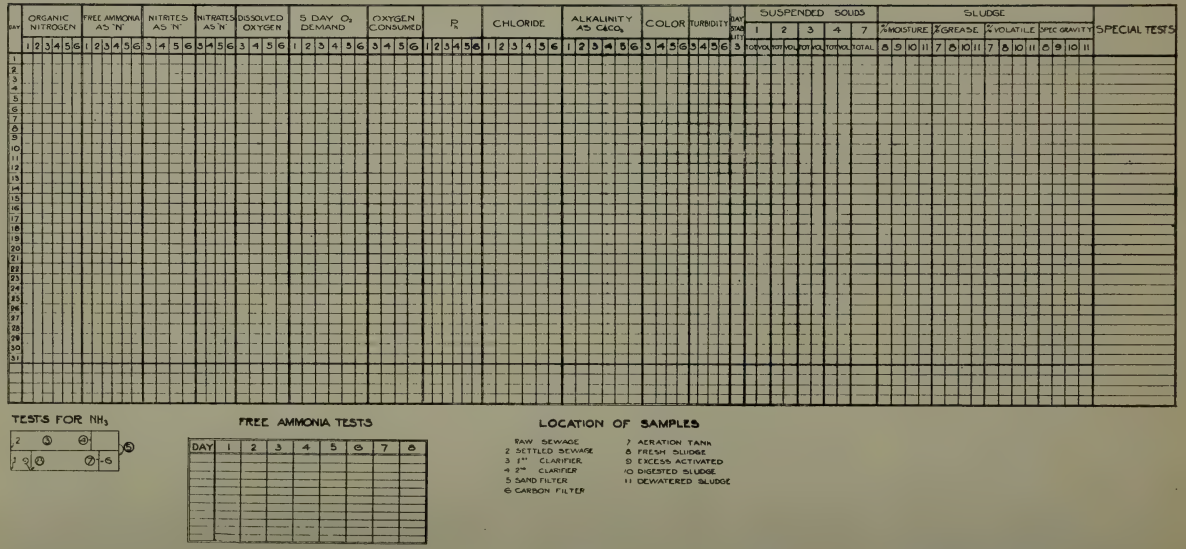
The overflow liquor is still further reduced by drawing off ripe sludge as new sludge is pumped into the digester. The remaining overflow liquor is not returned to the sedimentation tanks, but is placed on sand beds. Experiments are being made on the separate conditioning of overflow liquor for filtration and the conditioning of digested sludge for mechanical filtration to do away with all sand beds. The cake is in suitable form to be hauled away for use as a fertilizer.

It is proposed to conduct experiments with yeasts and enzymes in the digestion tank to accelerate digestion and gas production. A Ford gas engine connected to a motor used as a generator has been installed and the amount of power which can be generated from the sludge gas is being determined. It is already apparent that in a large plant receiving normal sewage, enough power may be developed to meet all its needs. In the experimental plant, the cooling water is used to heat the digester, there being probably three times as much heat from this source as is needed by the digester.

Experiments are also being conducted on the value of sludge for fertilization of various plants and trees.

Cost Data—A complete record of operation costs is maintained. Designs have also been made for activated sludge plants of complete design for the following sizes: 1 m.g.d., 10 m.g.d., and 25 m.g.d. The installation cost covering excavation, concrete, equipment, installation of equipment, and miscellaneous items has been determined and studied. This cost varies from $135,000 per m.g. for the small plant to $56,000 per m.g. capacity for the large plant. The operation costs are properly interpolated to the larger plants, and with the size of every piece of machinery and motor known. The power and depreciation costs have been accurately determined. For a 25-m.g.d. plant of the activated sludge process without filtration, the operation cost figures $15 per m.g., including: labor—$3.66, power—$1.65, chemicals—$2.50, depreciation—3.21, research—$1.00, maintenance—$0.50, and contingency—$2.04 15.8%).

Separate cost figures will be worked out for each new successful scheme of treatment, so that the true value of all improvements can be determined. It is not so much what antiquated plants in the east and here cost, but what a new plant designed on our present knowledge can be constructed for under local conditions. It appears that further revisions will be sharply downward.



TESTS FOR NH_3

FREE AMMONIA TESTS

DAY	1	2	3	4	5	6	7	8

LOCATION OF SAMPLES

1 RAW SEWAGE
2 SETTLED SEWAGE
3 1st CLARIFIER
4 2nd CLARIFIER
5 SAND FILTER
6 CARBON FILTER
7 AERATION TANK
8 FRESH SLUDGE
9 EXCESS ACTIVATED
10 DIGESTED SLUDGE
11 DEWATERED SLUDGE

Form Used at Los Angeles Sewage Reclamation Plant to Show Sanitary Chemical Analyses at Headworks.

These data do not include any return from the sale or use of water or the sale of sludge for fertilizer.

What the Plant Is Accomplishing—Although the major work along research lines has yet to be concluded, nevertheless the plant has already dispelled certain previously mooted points and demonstrated that reclamation is really within reach.

It has shown that sewage can be completely treated without nuisance, offense, or production of any odors.

It has shown that industrial sewage, including cannery, film and soap wastes, by adjustment of pH, increasing air, and increasing the reaeration period, does not upset an activated sludge plant.

It has been shown that the costs of activated sludge plants built under local conditions are not as high as necessary at eastern plants, and that the gross cost of operation by attention to details of operation, selection of equipment, and intelligent supervision, need not exceed $15 per m.g.

It has been shown that complete treatment producing drinking water which is devoid of suspended solids, oxygen demand, odor, taste, color, or smell, and which meets the Treasury Department standards, costs less than untreated water brought in from outside sources.

It has been shown that all visitors are favorably impressed and that no one who has been tolerant enough to investigate has any psychological or sociological objections to the final effluent, formerly discharged to the ocean, being placed into gravels above infiltration galleries.

It has been shown that by designing, building and placing into operation a complete plant within four months time, and further by developing activated sludge in seven days and sufficient gas in ten days to operate the digester, that a large plant using no other types of machinery than installed at this plant could in case of emergency be constructed even in less time.

INDUSTRIAL WASTE COMMITTEE

The following report was presented at the October, 1929, meeting in Oakland and on motion from the floor the committee was continued for another year. It was hoped that a model ordinance or some other concrete suggestion might be presented, but that has been difficult of accomplishment, both by reason of technical problems of waste disposal, and legal questions. The report is presented as a recital of experiences which should form the basis of future progress. It is hoped that members will find this report profitable, and if interested will send suggestions to the committee.

REPORT OF COMMITTEE ON THE LIMITATION OF DISCHARGE OF INDUSTRIAL WASTE INTO SEWERS

At the California Sewage Works Association's annual meeting held at Fresno, Mr. Harold F. Gray made a motion empowering the president, Leon B. Reynolds, to appoint a committee to report on the limitation on discharge of industrial wastes into sewers. On May 2, 1929, five members were assigned the task of collecting data on this vital matter.

Questionnaires were prepared and mailed to 49 cities in the State of California, 14 states in the United States, to Hawaii, making a total of 64 questionnaires; of which number 45 replied.

We are pleased to state that we have received a great deal of encouragement from many cities in California and other states. The great number of replies received indicate that this is a problem that needs considerable study.

The accompanying chart herewith is made up from the answers to the questionnaires and shows more clearly the results of the investigation. Some of the cities furnished information in the form of ordinances and detailed descriptions of their particular problems which were too lengthy to place on the chart, but are made a part of this report.

New Orleans

Geo. G. Earl, of New Orleans, writes as follows:

At New Orleans, any discharge into the Mississippi river well below the surface into the current, constitutes a satisfactory disposal for substantially any amount of almost any character of liquid waste. There is infinite dilution with a water which is usually quite turbid and always highly charged with dissolved oxygen.

The interesting thing in connection with the New Orleans experience is that the dry-weather flow and very small storm-flow drainage, due to street and yard washing, etc., and the conditions which arise in large drain collection give a collected flow which is just as objectionable as the flow which is rapidly collected through the separate sewers.

The storm-water drainage discharge has to be made into tide-level levee outfall canals entering tidal lakes, whose waters are frequently low in dissolved oxygen.

To avoid objectionable conditions in these outfall canals, more and more dry-weather flow drainage is having to be sent to a river outlet.

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REPORT OF THE LIMITATION OF DISCHARGE OF INDUSTRIAL WASTE INTO SEWERS—OCT. 8, 1929.

NO.	CITY	POPULATION	INDUST. WASTE PROBLEM	SEWERS SEPARATE	SEWERS COMBINED	TYPE OF INDUSTRY	QUANTITY	CHARACTER	CHARGES	REMARKS
1	Alameda, Calif.	38,000	no	yes						Empties into Bay.
2	Chico, "	12,000	no	yes		Dry milk factory.	Small			Dry milk factory disposes of its wastes separately.
3	Eureka, "	20,000								Only problem garages dumping oil to sewers.
4	Fresno, "	65,000	no							Septic tank and sewer farm.
5	Livermore, "	3,000	no							Imhoff tank.
6	Lodi, "	7,000	yes	storm	yes	Cannery, creamery, ice cream & ice.	300,000 gpd	Acid with high B.O.D.	Govm.by ordinance	With cannery running, plant is run at full capacity - all compressors working.
7	Los Angeles, "	1,448,000	yes	yes		Can., meat pack., dye, laundries, oil, etc.			no	Sewage passed through fine screening plant - removed solids from 1/16 inch up.
8	Madera, "	5,000	no							Imhoff tank, trickling filter.
9	Marysville, "	7,500	no							Sewer farm.
10	Merced, "	6,500	no							Ponds.
11	Modesto, "	20,000	yes		part.	Can., chem., milk & gas plants.	Not known	Dilute	no	Bar screens & settling tanks at industrial plants. H_2S from Barium Prod. Co. reaches septic tank.
12	Ontario, "	15,000	yes	yes		Canneries, grease byproducts.	Small		no	Canneries have own sewer to waste land. Large part of waste dehydrated at plant.
13	Pomona, "	25,000	yes			Paper mill, canneries, citrus packing.				Probable future treatment: Paper mill-Oliver filter; canneries-removal of solids
14	Porterville, "	7,500	no							Imhoff tank, intermittent sand filters.
15	Red Bluff, "	3,500	no	yes						Septic tank.
16	Richmond, "	20,000	no							Empties into bay.
17	Riverside, "	33,000	yes	part.	part.	Fruit packing & canneries				Sewer farm.
18	Sacramento, "	113,000			yes	Fruit canning, creameries.	Not known	Dilute	no	No treatment.
19	Salinas, "	8,000	yes	yes		Canneries and milk plants	Not known		no	Treatment plant under construction.
20	San Bernardino, "	42,000	no							Pre-chlo., Imhoff tank, trick.filters, final settling. Gas from sludge digestion used for fuel.
21	San Diego, "	160,000	no	yes						Empties into ocean.
22	San Jose, "	70,000	yes		yes	Canneries, distillery, gas plant & garages.			no	Outfall into bay. Cannery wastes put through grinding machine and flushed into sewer.
23	San Rafael, "	8,500	no	yes					no	All sewage pumped into San Francisco Bay.
24	Santa Ana, "	38,000	yes		yes	Canneries	20% of sewage	Seeds & fruit skins.	no	Solids removed at screening plant.
25	Santa Barbara, "	36,000	no	yes		Laundries	Not known		no	Fairly fresh domestic sewage passed through fine screens (Dorrco). Effluent to ocean, 3200' out.
26	Santa Cruz "	17,000	no	yes		Gas works and tannery		Chiefly tannery	no	Solids removed from tannery waste at plant, disposed by dilution to Pacific Ocean.
27	Santa Rosa, "	12,000	yes	yes		Canneries and fruit canneries.		Lime, hair, grease and fruit waste.	no	Frequent clearing of sewer mains necessary.
28	Stockton, "	55,000	yes	yes		Canneries, paper prod., & wool scouring.	Not known			Wool scouring and paper wastes discharged to river. Canneries rough screen & settle waste.
29	Turlock, "	6,000	yes		yes	Canneries and dehydrators			no	Water from washing fruit contains large quantities of caustic soda.
30	Ukiah, "	3,000	no	yes					no	Imhoff tank.
31	Vallejo, "	26,000	no		yes	Mare Is.Navy Yard dry docks				Navy Yard has entire separate sewer system on Island.
32	Ventura, "	14,500	no							Empties into ocean.
33	Visalia, "	6,500	yes	yes		Two canneries handling chiefly peaches.	1,000,000 g.p.d.	Peaches,skins and pulp.	no	Imhoff tank and sewer farm.
34	Yreka, "	3,000			yes	Creamery	Not known		no	Imhoff tank.
35	Yuba City, "	3,500			yes	Canneries & packing houses.			no	Sewage to ponds where septic action takes place.
36	Birmingham, Ala.	227,000	yes	yes		Engraving plants, gasoline stations & laundries			no	
37	All cities, Fla.	1,500,000	no							
38	Honolulu, T.H.	111,000	no	yes		Pineapple canneries	Not known			
39	Decatur, Ill.	50,000	yes		yes	Corn products	6,000,000 g.p.d.	Wastes have BOD 1.6 - 2. X ave.sew.	no	Corn products waste discharged to city sewer system and treated at sewage treatment works.
40	New Orleans, La.	450,000		storm	yes	Alcohol, oil, gas plants & turpentine distillery.			no	No treatment. Sewage and dry weather drainage discharge through pres. mains to Miss. River.
41	Worcester, Mass.	200,000	yes	64%	36%	Wire, carpet, tannery, slaughter & machine tools.	Not known	Grit, acid, lime, dye & tanning liq.	no	Grit chambers, car screens, Imhoff tank, dosing tanks, trickl.filters and final settling tanks.
42	Bad Axe, Mich.	3,000	yes		yes	Milk condensery, cottage cheese & butter factory.	36,000 g.p.d.	Milk, highly acid	7¢ / 1000 gal.chem.	Lime and copperas added to trade waste separately. Com. & storm to Imhoff tank & sand filters.
43	Jackson, Miss		no			Tramway and cheese plant.			no	
44	Pendleton, Ore.	7,500	yes		yes	Woolen mills and flour mills.		Dye from wool mills & wheat from wash.	no	No treatment. Dye water sufficiently diluted to avoid trouble but sewer fills up tanks.
45	Reading, Penn.	116,000	yes	yes			3,000,000 g.p.d.	Variable	no	Sewage treatment, sedimentation, trick.filter and final settling. Plant expan. in progress.
46	Fort Worth, Tex.	160,000	yes	yes		Packing houses	2,500,000 g.p.d.	Screened & settled packinghouse waste.	no	Rotary screens and corr chlorinators at packing houses make effluent fit for city sewers.
47	Haskell, Tex.	3,000	yes	yes		Laundry	50% of sewage	Strongly saline water	no	Control acidity by adding lime using La Motte pH control apparatus.
48	Itasca, Tex.	1,000	yes	yes		Cotton mill	Small	Highly concentrated	no	Planning to treat the industrial wastes. Settling, separate lime disposal, on land.
49	West, Tex.	3,000	yes	yes		Milk station	10% of sewage	Diluted	no	Provide preliminary settling for milk waste before it reaches tanks.
50	Jacksonville, Tex.	8,000	yes	yes		Laundry and creamery		High B.O.D.	50¢ / mo. per conn.	Settling tank, separate sludge digestion, contact aeration, trick.filter & final settling tank.
51	Kerrville, Tex.	5,000	no		yes					75% 75 pop. lysol and other disinfectants admitted to sewer. Lines also flush. Diluted with water.
52	Nacogdoches, Tex.	6,000	yes	yes		Small canning plant			House-yes Indus-no	Plant cans tomatoes. Waste discharged to creek.
53	San Marcos, Tex.	5,000				1 small creamery, 15 garages				Activated sludge.
54	Houston, Tex.								yes, see ordinance	Activated sludge.
55	Oakland, Calif.	350,000	yes	part.	part.	Diversified	Not known		no	Empties into bay.

31	Vallejo "	26,000	no		yes	Mare Island Navy Yard				Navy Yard has entire separate sewer system on Island.

The separate collection of domestic sewage is necessary because dry-weather sewage flow in the large storm-water drains of New Orleans would create intolerable conditions, and because complete sewage collection can be made many years before the whole city area can have underground drains on every street adequate for sub-surface removal for the very intense rains which New Orleans frequently experiences.

With occasional rainfalls of high intensity, however, all drains and all sewers are overcharged, and there is at such times little advantage in the separate collection system, since no treatment plant would provide for the quantity of sewage which would be collected if the separate sewers all along the line were made large enough to take all of the ground water which could enter them through 80,000 six to four inch terracotta house-connection lines, laid with cement joints (made as carefully as possible) when storm drains are overcharged. Sewage enters the sewers under a superior pressure to ground water. Sewage service, therefore, does not suffer, but the idea that where treatment is necessary for sewage, a lower capacity treatment plant can be attained by the separate system, is not sustained as applied to New Orleans conditions. The sewers, at maximum run-off conditions, when everything is overcharged for short periods, are going to have to be relieved into the main drainage outlets, and the main drains under dry weather and very small storm conditions are going to carry a character of flow which will just as much call for purification as the dry-weather flow in the sewers.

The problem, therefore, gets down to a question of how much total flow must be taken care of by purification or by discharge to distant or difficult outlets.

The advantage of the separate sewer system over the combined system, is that the sewers have not accumulated deposits to be flushed out when storms increase the discharge into them, and the large local storm drains have much less of objectionable deposits to be flushed out when storms occur than they would have if they carried domestic sewage.

The water supply of New Orleans averages now around 50 m. g. d., and the sewage collection during dry weather is not materially larger. We are, however, working toward a river outlet discharging capacity of 250 m. g. d., with the hope that we will thus be able to avoid objectional conditions in the tide level outfall canals or in the lakes into which they discharge.

Our maximum aggregate present storm-water rate of pump discharge into such canals, is now 8000 c. f. s., which is being increased by additional pumping capacity to 16,000 c. f. s., with 14 ft. diam. runner screw-pump units, each of 000 c. f. s. capacity.

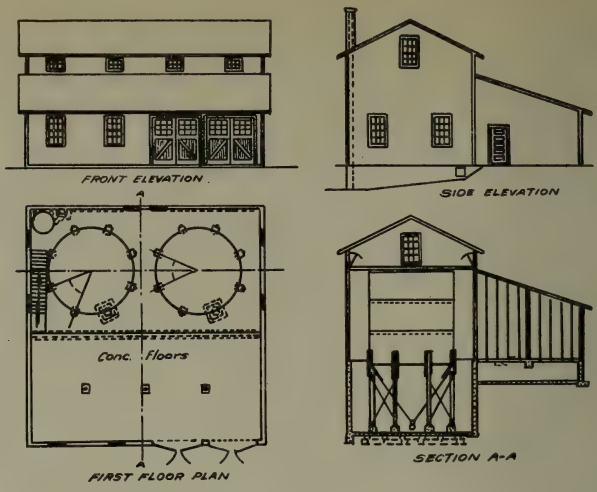
My belief that all sewers and drains will be overcharged at times is because we have had water falling on the 30,000 acres which these pumps must drain, at an average rate of 2.2 in. per hour for a three-hour period, which means 66,000 c. f. s. of rain falling on 30,000 acres for three hours, and have (eight times since 1894) had rains recorded at one or more of our six rain gauges of 5 in. or over (up to 7.88 in.) in five hours, which means from to 1.57 c. f. s. per acre of rain falling for five hours; and because for 15-min. periods, which represent collection time to our nearest pumping stations, we have recorded rates of rainfall of from 5 to 9 c. f. s. per acre.

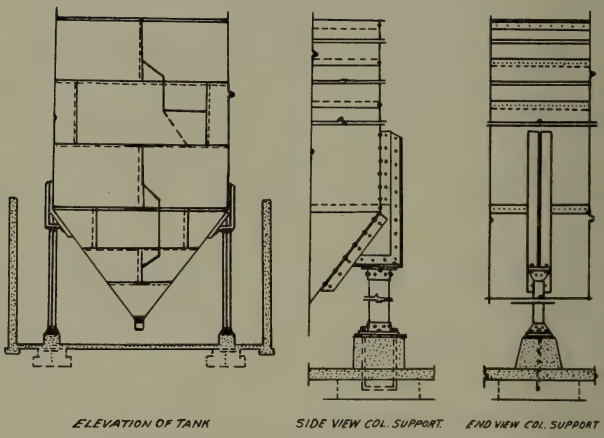
With all rain-water discharge depending upon pumping through one or more lifts, it is hardly probable that New Orleans can prevent overcharged drains under these occasional conditions of rainfall, when other cities having natural gravity outlets have never been able to build and maintain drains that are not overcharged when, less frequently, they get anything even remotely resembling such rainfall intensities.

Bad Axe, Michigan

Wade H. Foster, of Bad Axe, Michigan, describes their remedy as follows:

One of the greatest mistakes a city can make in the treatment of sewage is to attempt to take care of heavy trade wastes from creameries, canneries,





Disposal Plant for Creamery Waste, Bad Axe, Michigan.

tanneries, paper mills, etc., along with the domestic wastes. Here in the c of Bad Axe, we have been in a position to study this problem of trade was for the past six years.

The city, with a population of 3000, is almost entirely sewered. The sew is treated by means of a small Imhoff tank and sand filters. Trouble develo in the operation of the treatment plant on account of the continual clogg of the sand filters. The Imhoff tank did not seem to be at fault. A b investigation showed that the trouble was caused by a milk plant connecte the system. This plant was taking in from 40,000 to 80,000 lb. of skimmed m daily, and converting it into cottage cheese. The resultant waste amounte 25,000 gal. in a 10-hour day and constituted too great a load on the Im

tank. The waste, almost entirely in solution, would not separate or settle in the Imhoff tank, and the high acid content had a deleterious effect on germ life.

After some three years of experimentation and research with this problem, I developed and patented a treatment now known as the Foster Fill, Rest, and Draw Process, using lime and copperas as a coagulating medium. This system allows waste to be pumped in continuously, but draws off the clarified liquid in batches. The tanks take the place of and act as dosing chambers. Chemicals are deposited in the tanks automatically and the batches are agitated by air. The sludge is pumped out of the conical bottom at regular intervals. The tanks measure 16 by 18 ft., with 10-ft. conical bottoms, and are supported on 8 columns, as shown in the accompanying diagram on p. 80.

The plant is now taking care of 25,000 gal. of milk waste at a cost of 10 to 15c a thousand, depending on the density of the waste; and this is paid for by the milk company. The Imhoff tank is now performing much better than formerly.

The sludge from the tanks is of a dark green color. It has no odor, dries rapidly, can be easily handled, and is said to have value as a fertilizer. It is being tried by farmers on their fields.

Previous to the construction of the new plant, the conditions created by the creamery wastes and the overloading of the treatment plant were causing a good deal of trouble. The bottom of the ditch into which the plant effluent was discharged was covered with a black slime and offensive odors were present at all times. The farmers living along the stream were obliged to keep their doors and windows closed on warm summer nights; cattle drinking the water developed dysentery, some young stock even dying from the effects; and fish life was made impossible. These conditions existed as far down the stream as eight miles.

After the chemical plant had been in operation a few weeks, these conditions were relieved, the farmers became satisfied, and the injunction pending over the city was raised so long as the present conditions obtain.

After some use of hydrated lime, it was found better to use ground quick lime, testing about 96% calcium oxide. This lime comes to us in multi-walled paper sacks, air and water proof, and about 150 lb. is used for each 18,000-gal. tank.

When a tank starts to fill, about 50 lb. of lime is thrown in. When about one-third full, the operator adds a few drops of phenolphthalein indicator. If a caustic condition exists, the reaction will be very red; if it is only pale, another 50 lb. of lime is added. When the tank is about full, the operator checks back on this test by fading back a 50 c. c. sample of the lime-treated waste, before any copperas has been added, with tenth-normal hydrochloric acid. This should require from 2 to 3 c. c. By this method, we use enough lime, but avoid wasting it.

It has been found that the best results have been obtained by applying the copperas after the alkilinity has been built up. Each tank is provided with a wire basket held above the water by a cable running over a pulley, and in this basket about 40 lb. of copperas is placed at any time while the tank is filling filled. When the tank is full, the float action which diverts the incoming sewage to the empty tank lowers this basket into the water and turns on the air, thus dissolving the copperas and thoroughly mixing it with the lime. Copperas is purchased in car-load lots and is packed in barrels containing 400 lb. each. Crystal copperas has been found to keep and to dissolve better in the basket than the powdered copperas.

During March, 1928, we treated 612,000 gal. of creamery waste at a cost for chemicals of $59.04, or about 10c for each 1000 gal. After sizing it all up, we do not consider this cost prohibitive. It should be remembered that we are treating a concentrated waste containing no cooling water, as this is all passed to the stream. The average daily cost for the month was thus $1.97, with an average of 60,000 lb. of skimmed milk manufactured into cottage cheese. At present, we are not filtering the clarified effluent, as experiments indicate little benefit. It can be accomplished, however, at a high rate.

This treatment plant was constructed by the Belle Isle Creamery Co., of Detroit, at a cost of $10,000. It is open for public inspection.

Houston, Texas

Houston, Texas, regulates the waste by ordinances and fixes charges according to agreement as described in the following ordinances:

Be it ordained by the City Council of the city of Houston:

(a) It shall hereafter be unlawful to discharge, place or deposit into any public sewer, catch basin or drain in the city of Houston, except upon the terms and conditions hereinafter provided, any butcher's offal, garbage, dead animals, or any gaseous, liquid or solid matter or material other than ordinary house sewage, or to cause any matter or material of any kind whatever to be placed, thrown or deposited therein so as to obstruct the ordinary flow of sewage, or to discharge therein any oil, gasoline, gas, residuum of gas, calcium carbide, tar, or steam from steam boilers or engines, or water having a greater temperature than 110° F.,or to discharge therein any manufacturing waste or greasy waste from engines, laundries or other sources in such an amount as to tend to clog, block, obstruct or injure the sewer or to make it unsafe to enter therein for the purpose of repair or maintenance, or which may interfere with the effective operation of any sewage treatment or disposal plant.

(b) Every person, firm or corporation heretofore permitting or causing any such matter or material to be discharged or deposited into any public sewer, drain or catch basin shall make provision to discontinue such practice within five days after receiving notice from the City Engineer so to do. Failure or refusal to comply with such notice shall constitute an offense, and each day that shall elapse after five days from the date of the receipt of such notice shall be considered a separate offense, and such person, firm or corporation shall, in addition to the penalties hereinafter provided for, pay all reasonable expenses incurred or damages resulting from the violation of any of the provisions of this ordinance.

(c) In the event any person, firm or corporation produces butcher's offal or garbage, dead animals, blood, albuminous or colloidal matter, or any kind of trade waste whatever other than domestic sanitary sewage, and desires to discharge the same into a city sewer, the city may, at its option, enter into a contract with such person, firm or corporation to permit such discharge into the city sewer at a cost to be determined by the city, such contract to require such person, firm or corporation to install suitable apparatus for giving the trade waste or matter such preliminary treatment as the city may require, and for automatically and continuously measuring the quantity of sewage discharged into the city sewer. The city shall require a bond for the faithful performance of such contract.

(d) In the event that such contract as provided for in subdivision (c) hereof is entered into by the city and such person, firm or corporation so contracting permits material to enter the sewer in a different manner or of different quality or quantity than that provided for by the contract, or permits the treating plants or measuring devices to get out of order and remain out of order after being notified by the City Engineer to repair the same, such person, firm or corporation shall be guilty of an offense and shall be subject to the penalties hereinafter provided for, and shall in addition thereto pay all reasonable expenses incurred or damages resulting from the violation of the provisions of this ordinance, and each and every day that the said apparatus remains out of order after notification by the City Engineer to have the same repaired shall constitute a separate offense.

(e) It shall be unlawful for any person, firm or corporation, except authorized employee of the City Engineering Department to make any connection with any storm sewer of the city of Houston, and all such connection shall be made at the expense of the person, firm or corporation owning the industry producing water to be discharged into such sewer. Storm sewers are hereby defined as those sewers built exclusively for the handling of rain water and the washings from streets, having their own and independent outfalls into natural drainage courses and from which the discharge is not received into any disposal plant.

(f) It shall be unlawful for any person, firm or corporation to discharge ny sanitary sewage or any other material other than water and street washings nto a storm sewer in the city of Houston; provided, however, that large uantities of water such as produced by ice plants, swimming pools, natatoriums, undries and other similar establishments and industries shall, when required y the City Engineer, be discharged into storm sewers and not into sanitary ewers of the city.

(g) Every person, firm or corporation that has heretofore discharged ny waste or material into a sanitary sewer of the city which should according o the terms of this ordinance be discharged into a storm sewer, or vice versa, hall, within five days after receiving notice from the City Engineer so to do, iscontinue the practice of discharging such waste or material into a sanitary ewer or storm sewer, as the case may be, and upon failure to comply with ich notice shall be subject to the penalties hereinafter provided for, and each ay that shall elapse after five days from the date of the receipt of such notice hall be considered a separate offense, and he shall in addition thereto pay all easonable expenses incurred or damages resulting from the violation of the rovisions of this ordinance.

(h) Any person, firm or corporation, or agent or employee thereof olating any of the provisions of this ordinance shall be deemed guilty of an ffense and upon conviction thereof shall be fined in any sum not less than fty Dollars nor more than One Hundred Dollars.

Be it ordained by the City Council of the City of Houston:

Section 1. It shall hereafter be unlawful for any person, persons, firm or rporation to deposit, place or discharge into the Houston Ship Channel, twen Main Street Viaduct and Morgan's Point, or into Buffalo Bayou or hite Oak Bayou or the tributaries of either within or without the limits of the ty of Houston, either directly or through private or public sewers, any nitary sewage, butcher's offal, garbage, dead animals, gaseous, liquid or solid tter, oil, gasoline, residuum of gas, calcium carbide, trade waste, tar or use or other matter which is capable of producing floating matter or scum the surface of the water, sediment in the bottom of the channel or the odors l gases of putrefaction.

Section 2. Whenever it should prove to be impracticable in the judgment the City Engineer for the person, persons, firm or corporation owning or rating any property or industry producing any of the substances enumerated ve to discharge the same into the sanitary sewers of the city of Houston accordance with subdivision 21 of Section 1092 of the Revised Code of linances of the city of Houston of 1914, as amended on the 4th day of vember, 1918, such person, persons, firm or corporation shall construct a per treating or disposal plant to handle such substances before discharging liquid part thereof into any sewer pipe or drain leading into the Houston p Channel, between Main Street Viaduct and Morgan's Point, or into falo or White Oak Bayous or any of their tributaries. The design of such ting or disposal plant shall be submitted to the City Engineer for approval, the owner of such treating or disposal plant shall, after such approval, be onsible for its successful operation. The effluent from such treating or osal plant shall be free from matter that will settle in the bottom of the nel, from all floating matter, and from any matter that can putrefy and e offensive odors. Its ability to resist putrefaction shall be determined ollows: One cubic centimeter of a one-tenth per cent (1/10%) aqueous tion of Merck's methylene blue shall be added to two hundred and fifty) cubic centimeters of the liquid to be tested, and this colored liquid shall ncubated at thirty-seven degrees (37°) centigrade in a glass stoppered le; if the blue color disappears in less than forty (40) hours, the operation he treating or disposal plant shall be considered unsatisfactory and its thereafter discontinued until it is made to conform with the provisions of ordinance.

Section 3. Every person, persons, firm or corporation heretofore permitting using any matter to enter the Houston Ship Channel, or Buffalo or White

Oak Bayous, or the tributaries of either, contrary to the provisions of this ordinance, shall discontinue such practice within thirty (30) days after receiving written notice from the City Engineer so to do.

Section 4. In addition to the penalties hereinafter provided for, and cumulative thereof, the City Engineer is hereby authorized to use all physical means possible to prevent and stop the discharge of such refuse matter into Houston Ship Channel, Buffalo Bayou or White Oak Bayou or their tributaries and may seal or stop up any pipe, sewer or drain through which such refuse matter flows or empties into the streams and water courses hereinbefore mentioned, and such person, persons, firm or corporation owning or operating such property in violation of this ordinance shall pay all reasonable expenses incurred in enforcing the provisions of this ordinance, and all damages resulting therefrom.

Section 5. Any person, persons, firm or corporation, or any agent or employee thereof violating any of the provisions of this ordinance shall be guilty of an offense and on conviction shall be fined in any sum not less than Fifty Dollars nor more than One Hundred Dollars. Each day that such violation continues shall constitute a separate offense.

Flint, Michigan

From Flint, Michigan, a description and operating results of the largest treatment plant in that state are as follows:

Flint began the operation on October 10, 1927, of the largest sewage treatment plant in the state of Michigan. The completed plant will include bar screens, grit chambers, and sewage pumps, in a pumping station located within the city, to pump the sewage to the treatment works, which are located on a 135-acre tract of land about one mile northwest of the city limits, the nearest dwelling to which is about one-quarter mile distant. At present the treatment is confined to sedimentation in Imhoff tanks and drying the sludge, but it is proposed to add secondary treatment of the effluent, probably in the form of sprinkling filters.

Flint has a population of 150,000. It is primarily an automobile manufacturing city, and the industries contribute much oil and grease and both acid and alkaline trade wastes to the sewage, although a considerable part of this is disposed of by the industries themselves. Very little storm water reaches the sewers through rain-water leaders, and the average flow is only [illegible] million gallons per day from a connected population of 120,000.

The effluent from the treatment works is discharged into Flint river, which has a drainage area above that point of 980 square miles, and the flow of which varies from a minimum of 82 c. f. s. to a maximum of 1400 c. f. s., on a monthly basis. The absolute minimum recorded was in October, 1920, namely 58 c. f. s., and probably even smaller flows have occurred at times. During low flow the stream was badly polluted and there were unsightly sludge deposits and bad odors, and the State Board of Health several years ago ordered the city to take measures to prevent these, which it has now done.

At the pumping station are two screen and grit chambers built parallel. The pumping equipment consists of two 10 m. g. d. and two 15 m. g. d. 'American' sewage pumps, electrically driven with 125 hp. and 200 hp. motors. To provide against possible failure of the electric power, there is an auxiliary plant consisting of a Worthington 17 by 25 crude oil, full Diesel engine, connected to a 250 kva. Westinghouse generator. This unit is used for a short time daily to reduce the peak of consumption of electric current and thus materially reduce the power demand charges.

The pumps force the sewage through a 50-in. riveted steel force main to the treatment plant, where it passes through a 50 by 29-in. Simplex venturi meter. At the gate house the sewage rises in a surge well and flows over low weirs into two channels, each of which connects with a 30-in. cast iron pipe line which leads to two of the four Imhoff tank units. At present the effluent from the Imhoff tanks is discharged directly into the river.

Each of the four Imhoff tanks is designed for a capacity of 4 m. g. d., and s operated on the radial-flow plan. Each tank consists of 18 hexagonal cells, in an inner ring and 12 in an outer ring. Sewage is brought into the tank at he center, divides, and flows radially in every direction with a velocity lecreasing as it approaches the outside wall, where it is drawn off through 12 rifices placed around the wall, each orifice consisting of a 3 by 8-in. opening n a steel plate placed over the outlet of a pipe tee in a vertical riser pipe. These orifices are so adjusted that each will pass the same amount, so that he flow of sewage from the center of the tank to the outer wall will be uniform n all directions. Advantages of this arrangement are that the unusually low ate of sewage flow through the sedimentation compartments near the outlets ids in the removal of the finer suspended particles, which would not settle out n a tank giving a constant velocity through the sedimentation compartment; nd that the gradual reduction in velocity tends to stop eddy currents and thus creases the settling efficiency. The tops of the outlet pipes are left open s an emergency overflow and a scum baffle is placed around each orifice prevent oil, grease and other floating material from going with the effluent the filters.

Near each outlet orifice a skimming gate, fastened to the tank wall, skims f floating oil and grease and discharges them through the sludge pipe on to udge beds set apart for this discharge. These gates consist of 12 by 12-in. ownward-opening sluice gates, so designed that the top of the gate acts as a imming weir.

The sedimentation compartment of each tank is designed for a 4 m. g. d. te, figuring a 3-hour detention period with 4 m. g. assumed to come in hours, giving a nominal 4-hour detention period based on the average flow r 24 hours.

The sludge compartment of each tank is divided into 18 hexagonal pockets, e at the bottom of each cell. The inner row of pockets receives the heavier d more quickly settling sludge, which may be discharged by an air lift o one of the outer pockets, which transfer improves and shortens the diges- n process and eliminates the necessity for periodic reversal of flow. Sludge n be drawn off by gravity from the outer pockets to the sludge beds. The al sludge volume provided for is based on the unit of 2.75 cu. ft. per capita, h each tank designed for a population of 40,000.

The gas vents, one in each cell, cover 10½% of the total area of the tank. ey are carried up to a point 5 ft. above the normal sewage level and 2 ft. ve the side walls.

There are 40 sludge beds, each 24 by 125 ft., built with tile underdrains ered with gravel and sand, with division walls of cypress planks held in ce by means of pre-cast slotted concrete posts. The total area of sludge s gives 0.75 sq. ft. per capita of tributary population. A 24-in. gauge ustrial track is laid in each bed and connected to a track surrounding the t, which leads to a ravine nearby where the sludge is dumped.

Water is supplied for the plant by means of a deep-well pump with a acity of 50 g. p. m., which discharges into a 50,000-gal. elliptical-bottom ated water tank.

The cost of the plant was $17,433 for land, etc.; $219,650 for the pumping ion; $268,560 for the pressure main; and $541,887 for disposal plant; giving otal cost of $1,047,530. It is estimated that an additional $500,000 will be ired for completing the plant for secondary treatment.

The plant had been operated for fifteen months at the time of the latest rt. During that time the maximum amount of sewage received in any day was 16,180,000 gal. following a steady two-day rain, while the minimum unt of 6,250,000 gal. was on the last day of a dry month. The comparison he sewage flow with the rainfall record would indicate that the fluctuation ewage is due more to ground water than to storm water from roof drains, This is shown by the peak flow in April when the spring thaws occurred, precipitation being practically the same as during the previous month; reas after April, when the ground had thoroughly thawed out, the sewage followed the precipitation closely, probably due to a combination of roof ns and ground water, although the effect of the ground water would not

be as great as formerly, owing to the dry condition of the soil. In fact, during the peak precipitation in October, which was taken up by a very dry soil, there was little effect on the sewage flow until the following month. Roof drains still have a considerable effect on the sewage flow, however, for it is seen that in general a peak of sewage flow follows within a half and hour after each peak of heavy rainfall.

The sewage as received at the treatment works is septic, dark colored, considerably above the average in concentration as compared with sewage other cities; the average total solids being 928 p. p. m. and the average suspended solids 255 p. p. m. The B. O. D. is very high, the 5-day demand averaging 326 p. p. m. The septic nature also causes strong odors and is the subject of considerable study and research at the plant.

The population equivalent of the raw sewage, as computed from the customary value of 0.17 lb. of oxygen demand per capita per day, gives an average equivalent contributing population of 152,000. As the actual contributing or connected population is only 120,000, the local sewage is 1.27 times as strong as the average sewage; or in other words, the industrial waste adds the equivalent of the sewage of 32,000 people. The pH varies from 7.0 to 8.5 the oxygen consumed from 36 to 126, the 5-day B. O. D. from 132 to 95 total solids from 663 to 1808, the total organic solids from 209 to 1443, the suspended solids from 88 to 976, the suspended organic solids from 52 to 78 the turbidity from 125 to 800.

The regular operating force at the treatment works consists of the chemist in charge, an assistant chemist, two attendants, and one laborer, with additional laborers employed during the summer months to dispose of the sludge.

The efficiency of the Imhoff tank in removal of solids exceeded expectations the average removal for the year being 66.7%, but for the last 6 months nearly 75%; the low average during the early months having been due to reduced efficiency in May and June owing to initial operating difficulties, mostly foaming.

The solids in the sediment appear to be distributed uniformly, both throughout the tanks themselves and between the inner and outer rings of the cells. There appears to be little difference, however, in the digestion of the sludge in the inner and outer cells. One indication of this was that when the tanks started to foam, all cells formed practically simultaneously. Analysis of the sludge in the two sets of cells shows little difference in moisture or organic content.

The average reduction in organic matter in the sludge due to liquefaction and gasification during the year was 60.8%, while the reduction in dry solids for the same reason was 26.9%. The organic content of the raw sludge, which averaged 71%, is rather low for a sewage of this type, which may possibly be due to silt washed down with the storm water.

Foaming, which started in April and continued until June, was undoubtedly due to the time of year in which the tanks were placed in operation. Being started at a season when digestion is extremely slow, the tank became filled with raw undigested solids which, when the temperature became more favorable for digestion, proceeded to digest rapidly.

An oil separator was built, consisting of a wooden box mounted on an industrial truck, into which all skimmings are drawn before discharging to the bed. All oil is retained in the tank, the water escaping to the bed from the underdrain swing pipe. When the tank is filled with oil it is taken to a drain and the oil is discharged by lowering the swing pipe. This contrivance has satisfactorily solved the problem of disposal of oil and skimmings. The tanks are skimmed as often as is necessary to maintain good appearance, and the oil adhering to the tank walls is scraped off. The tank slots are cleaned with a chain pole when the occasion demands. All sludge lines are thoroughly flushed with water after use and any sludge slopping on to the masonry is washed.

During the last 6 months of the year, when operation was normal, the oxygen consumed was reduced by the tanks 41.4%, the 5-day B. O. D. 5-day total solids 22.2%, total organic solids, 27.8%, suspended solids 74.8%, suspended organic solids 72.3%, settleable solids 93.5% and turbidity 60%.

Sludge was drawn on to the drying beds for the first time on April 5, 1928. It was well digested, had little odor, and dried well considering the time of year. The average analysis of the wet sludge shows 92.9% moisture and 49.1% organic. All sludge beds were filled to an average depth of 12 in. The average shrinkage of the sludge on the beds was 71%; the average drying period was 33 days, with a maximum of 77 and a minimum of 9 days.

The total operating costs from March 1 to December, 1928, when a full operating force was employed, were: Pumping station, $40,090; disposal plant, $21,427. The cost of operating the disposal plant was divided as follows: labor, $15,877; power, light, etc., $1275; supplies, $1985; special equipment, $167. On these figures and corresponding ones for pumping, as a basis, the total cost of operation for a year of both pumping station and disposal plant would be approximately $57,670, or 48c per capita of connected population, or 38c per capita spread over the entire population of the city.

The engineering department advocates the plan of paying for the operation by assessing the cost against water users. As the revenue for 1928 was approximately $1,057,000, the cost of sewage treatment was 5.46% of the water revenue; that is, the citizens could pay for the operation of the sewage plant by increasing their regular water bills by 5.46%.

The chemists in charge of the plant have been carrying on investigation and research, including a small experimental filter, an experimental garden to determine the value of Imhoff sludge as a fertilizer; experiments to determine the best paint to use about the plant where subject to sewage fumes, gases, etc.; a study of the industrial wastes issuing from the individual manufacturing plants and the best methods of disposing of them; locating and preventing odors in the sewer system throughout the city; and a thorough inspection of the river for 30 to 40 miles below the city about every 8 days, to keep track of the effect of the sewage effluent on the river, especially on the oxygen content.

Delaware, Ohio

Delaware, Ohio, and other cities in the state of Ohio, charge rental as shown by the following ordinances:

To provide funds for the Maintenance, Operation, and Control of the Sewerage System and Sewage Treatment Works of the City of Delaware, Ohio.

WHEREAS, the City of Delaware, Ohio, has installed a Sewerage System and Sewage Treatment Works, and

WHEREAS, it is necessary for the preservation of the public health and for compliance with orders of the State Department of Health, that said sewerage system and sewage treatment works be properly maintained, operated and controlled, and

WHEREAS, funds for the maintenance, operation and control of said sewerage system and sewage treatment works will not be available from the current operating revenue of the city, and

WHEREAS, the General Assembly of the State of Ohio has enacted a law, amending Section 4357 of the General Code to permit municipalities to assess and collect for the use of sewers, said charges to provide for the proper maintenance, operation and control of sewerage systems and sewage treatment and disposal works,

NOW, THEREFORE, Be it Ordained by the Council of the City of Delaware, State of Ohio;

SECTION 1. That the Director of Public Service be and he is hereby authorized and directed to manage and control the sewerage system and sewage treatment works in a safe, economical and efficient manner.

SECTION 2. That the Director of Public Service be and he is hereby authorized and directed to make such by-laws and regulations as may be deemed necessary for the safe, economical and efficient management and protection of

the sewerage system and sewage treatment works, and for the construction and use of house sewers and connections to the sewerage system; that such by-laws and regulations shall have the same force and effect as ordinances when not repugnant thereto nor to the constitution or laws of the State of Ohio.

SECTION 3. That the terms and conditions upon which the owners of lots and lands within the corporate limits of the City of Delaware, may connect to the sewerage system either directly or indirectly, shall be as follows:

ARTICLE 1. Charges shall be paid at the office of the Director of Public Service, and for each calendar year or part thereof they shall be in accordance with the following schedule of rates:

Dwellings and Apartments

One Family (one connection) $4.00 per annum.
Two Family (one connection) $7.50 per annum.
Two Family (two connections) $8.00 per annum.
Four Family (two connections) $15.00 per annum.
Others (for each family) $4.00 per annum.
For each additional family on the same connection $3.75 per annum.

Hotels

For each room with bath $1.75 per annum.
For each room without bath $1.00 per annum.

Rooming Houses and Fraternities

Four Dollars ($4.00) per annum plus One Dollar ($1.00) per annum f each person renting a room therein.

Stores, Restaurants, Offices and Mercantile Establishments

Private Toilets, each $4.00 per annum.
Public Toilets, each $8.00 per annum.
Kitchen Sinks, each $4.00 per annum.
Slop Sinks, each $2.00 per annum.

Factories and Shops

For each and every person employed or engaged in services on the premi in accordance with the following schedule:
Ten persons or less, each $1.00 per annum.
More than 10 and not over 25, 90c per annum.
More than 25 and not over 50, 80c per annum.
More than 50 and not over 100, 75c per annum.
All over 100, 60c per annum.

Churches

For each toilet, $2.00 per annum.

College

All college buildings and dormitories not subject to taxation shall grouped and the sewer rental fixed on a per capita student population: each registered student 75c per annum.

Hospitals and Sanitariums

Delaware Springs Sanitarium $100.00 per annum.
Jane M. Case Hospital $60.00 per annum.

Miscellaneous

For special cases which are not clearly defined in the above schedule, rates hall be established by Council upon the recommendation of the Director of Public Service.

ARTICLE 2. Charges shall become due and payable in advance on the rst day of January, April, July, and October. All bills not paid by the fifteenth f the month in which same becomes due shall be subject to a 10% penalty.

ARTICLE 3. Charges shall constitute a lien upon the property served by uch connections, and if not paid within ninety days, shall be collected in the ame manner as other city taxes.

ARTICLE 4. Charges for discharging industrial wastes into the sewerage ystem shall be fixed by the Director of Public Service and approved by Council.

SECTION 4. That the funds received from the use of sewers shall be eposited with the Treasurer of the City, and money so deposited shall be ept in a separate and distinct fund and shall be known as the SEWER RENTAL FUND. When appropriated by Council it shall be subject to the rder of the Director of Public Service and said Director shall sign all orders rawn on the Treasurer of the City against said fund.

SECTION 5. Funds received from the use of sewers shall be used for he payment of the costs and expenses of the management, maintenance, peration and repair of the sewerage system and sewage treatment works and ny surplus in such fund shall be used for the enlargement or replacement of he same or for the payment of the interest on any debt incurred for the onstruction of such sewerage system and sewage treatment works, or for he creation of a sinking fund for the payment of such debt, but shall not be sed for the extension of the sewerage system to serve unsewered areas nor r any other purpose whatsoever.

SECTION 6. That this ordinance constitutes a part of an emergency easure and shall take effect and be in force from and after its passage.

Cities in Ohio

Abstract from typical Ohio city ordinance where sewer rental is sed on metering.

(a) For any building or any premises discharging sanitary sewage or dustrial waste into the Sanitary Sewerage System, there shall be charged for first 20,000 cubic feet of water, or any part thereof, consumed or used on said premises, per quarter year, a rate of twenty-five cents (25c) per ousand cubic feet, as the same may be metered or otherwise measured; for ry one thousand cubic feet of water in excess of 20,000 cubic feet and not eeding 40,000 cubic feet, a rate of twenty cents (20c) per one thousand ic feet; for each one thousand cubic feet in excess of 40,000 cubic feet, a e of fifteen cents (15c) per one thousand cubic feet per quarter, except that minimum to be collected shall be seventy-five cents (75c) per quarter year part of a quarter year exceeding forty-five days.

It is evident, from the data received and tabulated, that there still ains a great deal of experimental work to be done. Also, some form plan of charges to industries for taking care of their waste uld be made.

We wish to thank everyone, who so generously responded to our iests, making this report possible.

Respectfully submitted,

COMMITTEE ON THE LIMITATION OF DISCHARGE OF INDUSTRIAL WASTE INTO SEWERS.

FRANK J. ROSSI,
Chairman.

ITEMS / UNITS		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
		EFFLUENT FROM UNITS																														
		METHOD OF SAMPLING		SOLIDS p.p.m.														NITROGEN p.p.m.															TEMP.
				Inorganic or Fixed			Organic or Volatile			Settlable																							
				Susp.	Solu.	Coll.	Susp.	Solu.	Coll.	Inorg.	Org.	Dissolved Oxygen	20 D. Ox.	Relative Stability	Oxygen Consumed	D.O.	Temperature	Organic	Albuminoid Ammonia	Free Ammonia	Nitrites	Nitrates	Total	Alkalinity p.p.m.	p.H.	Chlorides p.p.m.	Precipitate Metallic p.p.m.	Boron p.p.m.	Bacteriological c. per cc.	Colloidal Matter Chlorine Demand	Sludge
A																																
B	Raw Sewage Inlet																															
C	Grit Chambers																															
D	Bar Screens																															
E	Equalizing Tanks																															
F	Fine Screens																															
G	Presedimentation Tanks																															
H	Imhoff Tanks																															
I	Septic Tanks																															
J	Chemical Precipitation Tanks																															
K	Grease Removal Tanks																															
L	Aeration Tanks																															
M	Re-aeration Tanks																															
N	Trickling Filters																															
O	Intermittent Sand Filters																															
P	Contact Beds																															
Q	Clarification Tanks																															
R	Final Settling Tanks																															
S	Filters Effluent																															
T	Chlorination																															
U	Sludge Thickening																															
V	Conditioning Tanks																															
W	Filters Sludge																															
X	Drying Machines Sludge																															
Y	Digestion Tanks																															
Z	Supernatent Liquor																															
AA	Drying Beds																															
BB	Lagooning Sludge																															
CC	Trenching & Burying																															

ITEM	CAPACITY	PRESENT FLOW	CAPITAL COST		ANNUAL DEPRECIATION				OPERATION COST YEAR			OPERATION REVENUE	PAST OPERATION COST RECORDS BY YEARS					ADMINISTR. ENGINEER SUPERVIS.
			Buildings Tanks Housing Etc.	Electrical Equip. Pumps Piping Etc.	Bldgs. Tanks Housing Etc.		Elect. Equip. Pumps Piping		Salaries Wages	Power	Materials Supplies Minor Equip. & Repairs							
					%	Amount	%	Amount										
Raw Sewage Inlet																		
Grit Chambers																		
Bar Screens																		
Equalizing Tanks																		
Fine Screens																		
Presedimentation Tanks																		
Imhoff Tanks																		
Septic Tanks																		
Chemical Precipitation Tanks																		
Grease Removal Tanks																		
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Chlorination																		
Sludge Thickening																		
Conditioning Tanks																		
Filters Sludge																		
Drying Machines Sludge																		
Digestion Tanks																		
Drying Beds																		
Lagooning Sludge																		
Trenching & Burying																		
Grinding & Sacking																		
Dry Sludge Storage																		
Shipping & Handling																		
Experimental Plant & Equip.																		
Laboratory																		
Buildings																		
Grounds - Roads - Misc.																		

34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69
						SLUDGE FROM UNITS																															
						GAS PRODUCTION							NITROGEN p.p.m.								FILTERING ADDITIVE OR COAGULANT							MISCELLANEOUS							
Wet Sludge per mg.	Percent Moisture	Dry Residue	Dry Sludge per mg. Sewage	Total Solids p.p.m.	Volatile Solids p.p.m.	Volume	B.T.U. per	CO_2 per	Ammonia per	Nitrogen per	Hydrogen per	Grease	Organic	Albumoid Ammonia	Free Ammonia	Nitrites	Nitrates	Total	Phosphoric Acid p.p.m.	Potash p.p.m.	Name	Quantity per Unit	Seeding Rate	Reduction Turbidity	Reduction Volatile Solids	Reduction Dissolved Oxygen	Under Consideration	Velocity of Flow	Detention Period	Type of Filter	Filter per Gallon	Gallon per Sq. Ft.				

SUMMARY COST FORMS

Presented by Standard Report-Forms Committee at Long Beach—see p. 17.

SUMMARY OF REPLIES TO QUESTIONS ON ROOT TROUBLES IN *MUNICIPAL SANITATION* FOR DECEMBER, 1930

PLACE	Are roots troublesome?	Trees causing trouble	Method of preventing	Method of root removal
Providence, R. I.	Yes	(?)	Compound joints now used instead of cement.	Foundry brushes 1 inch larger than sewer diam. are drawn through sewers once a year by a truck.
Natchez, Miss.	Yes	Maple, pecan, oak.	Each cement joint covered with salt before backfilling.	Self-propelling nozzle used to cut roots.
Bloomington, Ill.	Yes	Carolina poplar.	Use cement joints.	Sewer cleaning machine with turbine and cutter blades. Pulled through sewer with windlass and cable.
Somersworth, N. H.	No		Brick sewer chiefly. Tile sewers have cement joints.	Root cutter on fire hose—seldom used.
Winona, Minn.	Yes	Elm.	Poured bituminous joints.	Kuhlman sewer cleaning machine used.
Danbury, Conn.	Yes		Tight joints.	(1) Use of general sewer cleaning apparatus. (2) Uncovering of lateral.
Fayettville, Ark.	Yes		Tight joints.	Root cutters fastened on end of sewer rods.
Norristown, Pa.	Yes	No. Carolina poplars, also willow and swamp maple		Rods and uncovering of sewer.

SUMMARY OF REPLIES TO QUESTIONS ON ROOT TROUBLES IN *MUNICIPAL SANITATION* FOR DECEMBER, 1930

PLACE	Are roots troublesome?	Trees causing trouble	Method of preventing	Method of root removal
Marinette, Wis.			Tight cement joints	
Gastonia, N. C.	Yes			(1) Turbine sewer cleaning machine. (2) Cable with chain links pulled through sewer. (3) Stewart sewer rods and cleaning tools used.
Orlando, Fla.	Yes		Bitumen joints on sewer laterals and mains, C. I. on house sewer.	(1) Rods and root cutters. (2) Digging up sewer and relaying with tight joints.
Elmira, N. Y.	Yes	Willows, elms, poplars.	Iron pipe or leadite joints.	Turbine sewer cleaning machine with revolving cutting knives.
Kenosha, Wis.	Very little		C. I. pipe and lead joints. Tight cement joints.	Sewer turbine with root cutting attachment. Digging up sewer and cutting of roots.
Alhambra, Calif.	Yes		To prohibit tree planting. (Not done)	Sewer cleaning rods, tools and appliances.
Austin, Texas	Yes		Cutting down all adjacent trees. Metal pipe, tight joints.	Sewer rods, cable sewer cleaners. Digging up sewer and relaying.
Owosso, Mich.	Yes		Well-made, sound, mechanical joints.	Sewer rods, turbine nozzles, cables. Excavate and relay faulty pipe.

SUMMARY OF REPLIES TO QUESTIONS ON ROOT TROUBLES IN *MUNICIPAL SANITATION* FOR DECEMBER, 1930

PLACE	Are roots troublesome?	Trees causing trouble	Method of preventing	Method of root removal
Kewanee, Ill.	Very little			Hand tools. Sewer rods, 1⅛-in. nozzle on fire hose.
Salisbury, Md.	Yes		Properly constructed, tight joints.	Excavate at entry of roots and re-lay sewer.
Warren, Ohio	Yes	Poplars.	Bituminous joint compound.	(1) Use root cutters. (2) Excavate sewer to remove roots.
Columbia, S. C.	Yes		Compound joints.	Root cutters.
Oregon City, Ore.	Yes		Tight joints.	Root cutters. Relaying of troublesome sections.
Glendale, Calif.	Yes		Tight joints. Prevention of sewer settling.	Cutters, fastened to sewer rods.
Fremont, Neb.	Yes		Tight joints.	Common root cutter.
Longmont, Colo.	Yes		C. I. in house sewer.	Self-propelling nozzle, or circular blade pushed ahead of a sewer rod.
Ithaca, N. Y.	Yes		Tight joints.	Wire brushers fitted with C. I. shoe are dragged through sewers with cables.
Mason City, Iowa	Yes		C. I. pipe in house sewers. Tight joints on sewers. City control of tree planting.	Sewer cleaning appliances.

MUNICIPAL SANITATION FOR DECEMBER, 1930

PLACE	Are roots troublesome?	Trees causing trouble	Method of preventing	Method of root removal
Parsons, Kans.	Yes		(?)	Dragging of sewers.
Easton, Pa.	Yes		Tight joints.	Root cutting tools and rods. Digging up sewer and relaying.
Albert Lea, Minn.	Yes		Prestite joints.	Champion sewer cleaning machine.
Oil City, Pa.	Yes, only in house sewers		Tight joints.	Re-lay house sewer with tight joints.
Zanesville, Ohio	Yes		Asphaltic joint compound now used.	Sewer cleaning machine, or relaying of sewer.
Janesville, Wis.	Yes		C. I. house sewers. Tight asphaltic joints.	Turbine sewer machine.
Nampa, Idaho	Yes	Poplars.	Tight joints.	Sewer dug up and replaced.
Owatonna, Minn.	Yes		C. I. pipe.	Hooks and rods, or digging up sewer.
Beloit, Wis.	Yes		Tight joints.	A pair of circular knives set on springs are dragged through the sewer.
Port Arthur, Texas	Yes		Salt on joints when laid, C. I. pipe.	Steel wire with cork-screw on end is used to remove roots.

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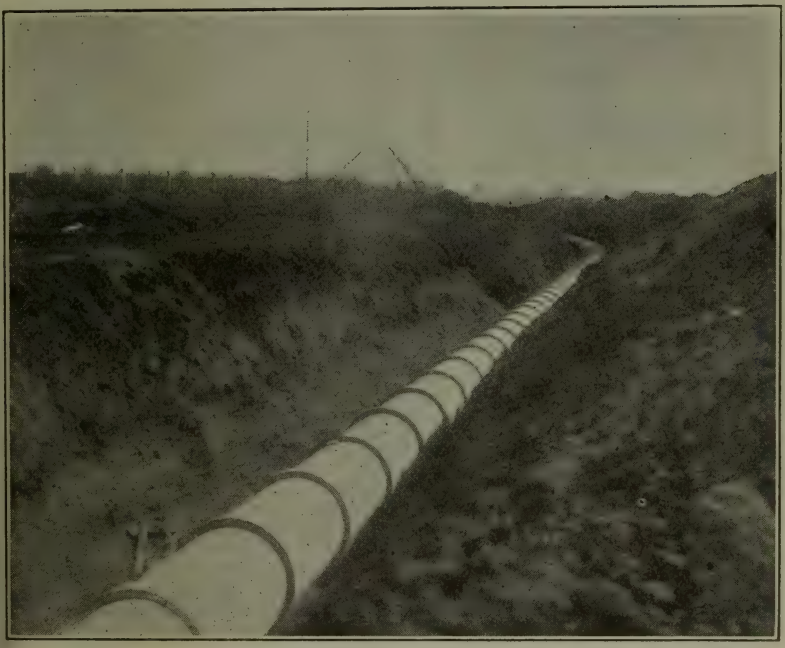

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CALIFORNIA SEWAGE WORKS JOURNAL

Official Publication of the California Sewage Works Association

VOL. IV • 1931 • No. 1

Proceedings of the
Third Spring Conference at Ventura
...and...
Fourth Annual Convention at Monterey

◆

Procedure for Making Annual Award of Merit

◆

Four Special Articles

◆

Memoir of Philip Schuyler

◆

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CALIFORNIA SEWAGE WORKS JOURNAL

Address all communications to the Secretary

Membership and Annual Dues $2.00

This Journal, together with the Journal of the Federation of Sewage Works Associations, free to members. Extra copies, $1.00.

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Printed by

WESTERN CONSTRUCTION NEWS, Inc.

114 Sansome Street, San Francisco, California

California Sewage Works Journal

Published by CALIFORNIA SEWAGE WORKS ASSOCIATION

The California Sewage Works Journal is not responsible, as a body, for the supposed facts and opinions advanced in any of the papers, discussions, or articles published in this Journal. Discussion of all papers is invited.

VOL. IV 1931 No. 1

CONTENTS

Officers, Directors, and Committees 6

Memoir of Philip Schuyler 7

Programs and Minutes

Program of Third Spring Conference at Ventura 8

Report of Third Spring Conference at Ventura—*Philip Schuyler* 9
(Including abstracts of three papers: Sewage Disposal at Santa Paula—*Harry E. Reddick;* Santa Barbara County Hospital—*Marion L. Crist;* and My Experiences with Ocean Outfalls—*C. L. Cooke*)

Procedure for Making Annual Award of Merit 21

Program of Fourth Annual Convention at Monterey 22

Report of Fourth Annual Convention at Monterey 23

Papers at Fourth Annual Convention

Aeration Experiments and Experiences at Salinas, California—*T. R. Haseltine* 31

Some Practical Improvements in Operation Resulting from Research at Griffith Park Experimental Station, Los Angeles—*R. F. Goudey* 38

Operation of Typical Sewage Disposal Plants in California and Comparison with Results Obtained Elsewhere—*E. A. Reinke* 42

CONTENTS (Continued)

The State Department of Public Health and its Relation to the Sewage Works Operator—*Giles S. Porter* 49
Yosemite Valley Activated Sludge Plant—*H. B. Hommon* 51
Sewer Ventilation, Why and How—*D. Donaldson* 63
Explosions in Sewers and Sewer Maintenance—*W. T. Knowlton* 68
Advances in Sewer Pipe Construction—*A. M. Rawn* 72
Control of Cannery Odors at Monterey—*H. D. Severance* 78
Legal and other Considerations on Sewer Rental—*Wm. J. Locke* 82
Sewage Disposal Out of California—*Clyde C. Kennedy* 85
Sewage Disposal Out of California—*Wm. A. Allen* 88
Recent Studies on Sludge Digestion—*A. J. Fischer* 91

Special Articles

"Slipseal" Precast Asphaltic Sewer Joint—*E. French Chase* 95
Refined Sewage Treatment Is Justified—*Carl Wilson* 98
Sewerage Improvements, Phoenix, Arizona—*W. J. Jamieson* and *Clyde C. Kennedy* 101
Salinas Sewage Treatment Plant—Results of First Year's Operation—*T. R. Haseltine* 111
Roster of Members, California Sewage Works Association 120
Advertising 126

The object of this Association shall be the advancement of the fundamental and practical knowledge concerning the nature, collection, treatment and disposal of sewage and industrial wastes, and the design, construction, operation and management of sewage works in California, through the interchange, between members of the Association and with others, of information, experience, and opinion relating thereto.

—Article III, Constitution C. S. W. A.

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1880-1931

Going through life, doing cheerfully each day and year the things that make the world a better place in which to live; constant in service to family and mankind; fostering harmony and good fellowship along the way . . . Such is the memory and inspiration Phil Schuyler leaves behind to all who were privileged to know him.

1931 SPRING CONFERENCE

California Sewage Works Association

VENTURA

March 23-24, 1931

Headquarters, Pierpont Inn

Program

MONDAY, MARCH 23

8:00 a. m.—Meet at City Hall, Santa Barbara.
Caravan will proceed to Santa Barbara County Hospital.

8:30- 9:30—Visit County Hospital plant, which includes preliminary and final settling, separate sludge digestion and a Watsco aerator.

10:00-10:30—Visit Santa Barbara Screening Plant.

10:45-11:00—Visit Carpinteria Sewage Pumping Plant.

11:30-12:00—Visit Ventura Screening Plant.

Noon—Spanish Barbecue, put on in real style by the City of Ventura.

2:00-4:00 p. m.—Meeting at Pierpont Inn, Ventura.
Discussion of plants visited, by M. L. Crist, L. R. Walker, F. L. Johnston, D. C. McMillan, H. K. Palmer, O. E. Steward and W. T. Knowlton.

6:30 p. m.—Dinner at Pierpont Inn, Ventura.
Motion Pictures by A. M. Rawn and C. A. Smith.
Talk by deep sea diver, who is an engineer and has inspected sewer outfalls in place.

TUESDAY, MARCH 24

8:00 a. m.—Meet at Pierpont Inn, Ventura.
Caravan will proceed to Santa Paula.

8:30- 9:30—Visit Santa Paula Imhoff tank and sewer farm.

10:30-11:30—Visit Ojai sewage disposal plant, consisting of sedimentation, sprinkling filter, secondary settling and sand beds.

Noon—Lunch at Wheeler Hot Springs.

2:30- 4:00—Meeting at Pierpont Inn, Ventura.
Discussion of plants visited, by H. E. Reddick, City Engineer, Santa Paula, and Mayor A. L. Drown, of Ojai.

THIRD ANNUAL C. S. W. A. SPRING CONFERENCE AT VENTURA, MARCH 23-24, 1931*

By PHILIP SCHUYLER†

The third annual spring conference of the California Sewage Works Association surprised the most optimistic in both attendance and interest shown.

Prior to the formation of the C.S.W.A., three years ago, it would have been well-nigh impossible to induce even as many as forty sanitary engineers, city officials, superintendents of sewers or sewage treatment plants, and representatives of equipment or material manufacturers, in all of the state of California, to convene for a discussion of sewage treatment and disposal. Therefore, when 130 answered the call, from all over the state, to meet at Santa Barbara for merely a two-day inspection and discussion of six sewage pumping, screening and treatment plants, it shows what the C.S.W.A. has already accomplished in creating public interest in a subject which heretofore has been looked upon as a necessary evil to be relegated as promptly as possible to "out of sight, out of mind", and never to be discussed if it could be avoided.

It is, therefore, particularly gratifying to see this rapid awakening of interest, and it now appears certain that the slogan of the pioneers in sanitation—"Keep California and the Far West Clean"—will become a reality. In this respect, Southern California is considerably ahead of Northern California. The Southern California communities are voluntarily, and without any particular pressure from the State Board of Health, constructing sewage treatment plants to prevent pollution of their ocean beaches, harbors and fishing grounds. The cities around San Francisco bay and on the Sacramento river particularly have not become as yet "sewage conscious," and pressure must be brought to bear to force them to take corrective measures.

Returning to the Spring Conference, the automobile caravan trip included: On Monday, inspection of a small sewage treatment plant at the Santa Barbara County Hospital, the ocean-outfall pumping and screening plant at Santa Barbara, the ocean-outfall pumping plant at Carpinteria, the ocean-outfall pumping and screening plant at Ventura, followed by a Spanish barbecue near Ventura, and open-air meeting at Ventura; on Tuesday, inspection of the sewage treatment plant and sewer farm at Santa Paula, the sewage treatment plant at Ojai, followed by a barbecue at Wheeler Hot Springs, and another open-air discussion meeting.

This program and all details of the trip were most carefully planned and supervised by a special committee consisting of: D. C. McMillan, city engineer of Ventura (chairman); L. R. Walker, assistant city engineer of Santa Barbara; Harry E. Reddick, city engineer of Santa Paula; and A. L. Drown, mayor of Ojai.

The caravan assembled at the City Hall in Santa Barbara promptly at 8 o'clock Monday morning, with 35 automobiles, which soon increased, en route, to 60 cars. Through the courtesy of Pacific Clay Products and Gladding, McBean & Co., each member, wife and guest

*Reprinted from "Western Construction News," April 25th, 1931, issue, p. 209.
†Managing Editor, "Western Construction News," died December 11, 1931.

was tagged with a name badge, and each automobile was numbered, front and rear, with a C.S.W.A sticker. The caravan was under the escort of three of the state's efficient traffic officers, thus insuring safe and rapid transportation for all.

Santa Barbara County Hospital—This sewage treatment plant was built in 1930, Burns-McDonnell-Smith Engineering Co., of Los Angeles and Kansas City, being the designing engineers. M. L. Crist, associate engineer with the firm, described the plant to the assembly. The present population of the hospital is 400, and the plant was designed for an ultimate of 700; the cost being $10,000.

Prior to 1930, the hospital had an "ancient" septic tank, which had never been cleaned, and which discharged into an open ditch, paralleling the state highway, and, needless to say, was a nuisance.

The present plant consists of a small Imhoff type, preliminary sedimentation tank (retention period 40 min.) with a very small sludge compartment, from which the sludge is pumped automatically by a 4-in. centrifugal pump, operating at present 1¼ min. every 2 hr., to the old septic tank, remodeled into a digester. Return sludge is added to the settled effluent from the Imhoff tank, and the mixed liquor flows to an aeration tank, 15 ft. in diam., equipped with a Watsco† aerator (designed by F. W. Hammerly of the Water Works Supply Co.). The retention period is 6 hr. at average design flow, plus 20% return sludge. The liquor then passes into a final settling tank, a steep-sided conical structure; entering at a point 7 ft. below water surface, and discharging over a peripheral weir. Settled sludge is withdrawn by a variable-speed, 1½-in. centrifugal pump, returning it either to effluent of Imhoff tank or sludge compartment of same, or both, to act like "yeast in bread."

In addition to the hospital sewage (consisting of 99.9% water and 0.1% solids), provision was made for treating the wash water from the hospital dairy; or for an average sewage flow of 30,000 g.p.d. plus 20,000 g. per 8 hr. from dairy, or total of 50,000 g.p.d. But it was soon found that the dairy operators would not clean the floors before washing down, the result being too much sludge for capacity of plant, although this strong dairy waste aided rather than retarded the sewage aeration. Therefore, at present the dairy washing waste is not discharged into the sewage treatment plant, although it will be when the dairy operation is improved. The Imhoff tank with small sludge capacity, requiring constant sludge removal, is very satisfactory. The Watsco aerator is very efficient, dissolved oxygen being easy to maintain, and it being possible to vary the air injected from zero to 45 cu. ft., the latter figure representing 1.3 cu. ft. per gal. of design sewage flow. Nevertheless, at this plant it has been found so far impossible to build up a heavy, dense sludge. Whether it is due to a breaking up of the sludge in the screw pump of the Watsco aerator or to some ingredient, or lack of same, in the sewage, has not been determined. Vertical sedimentation of light activated sludge in the final tank has been most effective in securing clarification. The effluent remains stable for 10 days. It is discharged into a dry water-course, although it could be used to irrigate a nearby alfalfa field and vegetables, if chlorinated.

†Now known as "Hardinge" aerator.

Santa Barbara Pumping and Screening Plant—This plant was described by L. R. Walker, assistant city engineer, who was the designer, and W. M. Neagle, superintendent of the plant. Prior to 1924, the sewage of Santa Barbara was discharged into the Pacific Ocean through 600 ft. of outfall after passing through a pumping and screening plant equipped with Riensch-Wurl screens. The 600-ft. outfall was reduced to 300 ft. by wave action, and it became necessary to build another outfall, etc.

After due consideration it was decided that complete treatment would be too costly; also there was no suitable land nearby for a plant.

The present pumping and screening plant was built in 1925 in a long, narrow park, shoreward from and parallel to the ocean beach drive; largely screened from observation by shrubbery, although the building is architecturally attractive. The plant consists of three Yeomans vertical sewage pumps—one 12-in. and one 10-in. with G. E. motors, and one 12-in. with a Western gas engine as an emergency unit. The electric-drive pumps are automatically controlled. The average daily sewage flow at present is 3,000,000 gal. There are also Dorrco screens, in duplicate, operated alternately for one week each. The screens are easily cleaned when not in use by distillate applied with a brush. The screenings, at present, are buried in trenches in the park adjacent, three times a day. Plans are being prepared for an incinerator, somewhat similar to the one at Long Beach. Sewage effluent flows into a flume, through a sand trap, and then through 3200 ft. of 42-in. concrete pipe outfall into the Pacific ocean at 40 ft. depth of water. The effluent is chlorinated, for odor control only at present, just beyond the sand trap, with 20 lb. of liquid chlorine per day, applied by Wallace & Tiernan chlorinators, in duplicate.

Carpinteria Pumping Plant—This plant, nearing completion, was described by F. L. Johnston, consulting engineer of Santa Barbara, the designer. The building is near the beach and is attractive architecturally, with a clay-tile roof. The equipment includes two Fairbanks-Morse-Wood trash pumps of 500 g.p.m. capacity each, the total lift being 50 ft. The wet well is large. The pumps operate automatically; first one cutting in, and then both if necessary. The plant is equipped with Bristol recording meters, and the charts changed weekly. There is also a Sturtevant blower which takes air through screened vents in a window in the dry pit and discharges into the wet well; the air then passing through a false chimney. The motor on the blower is interconnected with the pump motors for automatic simultaneous operation. The building, including pump pits, was built by the Harmon Co.; the pumps and motors, etc., installed by Fairbanks-Morse Co.; the cast-iron pipe was furnished by American Cast Iron Pipe Co.; and laid by A. H. Adams; the ocean outfall by Chas. H. Johnson, the pipe being furnished by Crane Co.; the vitrified pipe was furnished by Gladding, McBean & Co.

Carpinteria is a scattered community, with an estimated population of 2000, including many Mexican peons; the summer-time population being almost double this on account of the attractive sea bathing at this locality. The average daily sewage flow has not as yet been determined, as all the lateral sewers, etc., have not been completed.

C. S. W. A. Third Spring Conference (Upper Left) Sewage Treatment Plant at Santa Barbara County Hospital. (Lower Left and Upper and Lower Right) Ojai Sewage Treatment Plant.

Most of the territory served by the 6 miles of sewer mains (constructed under Improvement Act) is low in elevation, many of the sewers being below water level, and the main sewer entering the pumping plant 10 ft. below sea level.

The pumping plant was designed for 500 g.p.m., or a population of 3500 to 4000, and an ultimate of 8000 by making slight changes in the pumps; the outfall being large enough.

The ocean outfall consists of 3000 ft. of 8-in. Byers wrought-iron pipe, discharging at 50 ft. depth of water; plus 1000 ft. of cast-iron pipe-line from the pumping plant to the beach; the outfall being a gravity line.

The preliminary plans included the location of the ocean outfall at the southern end of the district, or lowest point of drainage. Subsequent detail studies of the wind and currents, by floats, etc., showed the sewage would return to the beach. Therefore, the location was changed to the foot of Palm ave., and it is anticipated (pumping of sewage has not as yet started) that the sewage will not return to the shore until 2 to 5 miles south, at a point unfrequented and of no use for bathing, etc. A profile of the ocean bottom was secured and a wrought-iron pipe-line determined upon as being preferable and cheaper for this outfall than concrete or cast-iron pipe. Surveys of the profile of the ocean bottom revealed the fact that 25% of the outfall (along the line of the breakers) is subject to frequent shifting of the sand, leaving ridges and reefs of rock. Divers were used to cut down the high points of the reefs, and concrete pillars were built between to secure a fairly uniform gradient for the pipe-line. The wrought-iron pipe-line was towed to sea and sunk to position by the oil-loading method; the outfall end being turned up 6 ft. Since the line was laid there have been no severe storms. The outfall end is now encrusted with barnacles and sea moss, inside and out, and chlorination is being considered as a means of preventing these growths on the inside of the pipe. The pumping plant and outfall sewer were built from bonds voted by a sanitary district, and operation of the plant, etc., will be somewhat hampered by the shortage of adequate funds derived from the 15-cent tax levy, unless the present State Legislature increases it.

Ventura Pumping and Screening Plant—D. C. McMillan, city engineer, described this plant, which was built in 1928. The original sewer system for Ventura was built by an engineer, George Powers, more than 50 years ago, and was operated with few changes or additions until 1927. It included an ocean outfall of 14-in. i.d. wrought-iron pipe, which was salvaged in 1928, and used in the storm-drain system. The present sewer system is quite extensive, as Ventura has grown and spread out very rapidly during the past few years of oil-well development. There are three main trunk-sewers leading to the pumping and screening plant, which is practically a duplicate of the Santa Barbara plant, with two Dorrco 6-ft. screens, pneumatic screenings-ejectors, etc. The pumps* are operated 5 min. out of every 20 min. The ocean outfall is 2100 ft. long, of copper-bearing steel pipe, with an exterior coating of mastic for the first portion and gunite for the remainder. Screenings are at present buried in sandy soil, but experiments are being made

*The pumps are Layne-Bowler. There is also an F. M. Co.-Woods trash pump, an Ingersoll-Rand compressor, and Bristol liquid-level recorders.

with a home-made centrifugal dewaterer, as the screenings analyse 44.4 lb. of nitrogen per ton.

There are now 50 miles of sewer mains in Ventura, from 4 to 30-in. diam., and 22 miles of house laterals; the total cost of installation being $345,774. The 2100 lin. ft. of 17¼-in. i.d. pipe ocean outfall cost $34,000. The pumping and screening plant cost $35,100 (building, $16,100; machinery, $19,000). The Beach sewage pumping plant, including 10-in. c.i. pressure pipe-line and Fairbanks-Morse pump, cost $9800.

Spanish Barbecue at Wren's Nest—The C.S.W.A.'s were the guests of John Largomarsino, and the Ventura Chamber of Commerce, of which he is president, at Wren's Nest, adjacent to Foster Park, which Largomarsino and a few friends own. These men personally cooked the barbecue, which was one to be long remembered.

Discussion Meeting—After the barbecue, the C.S.W.A. members held an outdoor discussion meeting in a small Greek amphitheatre in Foster Park, close by, where a more detailed description of each of the plants visited was given by Crist, Walker, Johnston and McMillan, followed by discussions.

H. K. Palmer, of the Los Angeles County Sanitation Districts, referred to tests made on mixing sewage with sea water. At the discharge end of the Santa Barbara ocean-outfall, the sewage flow is nearly continuous—9 min. out of 12 min. Palmer also stated it was desirable to use flexible couplings in concrete pipe-lines every 50 to 100 ft. to help prevent breaks in the line.

O. E. Steward, engineer for the Orange County cities joint outfall-sewer, told how only ten years ago the various cities had separate sewage disposal works. They were forced to combine, Santa Ana and Anaheim being first, and now 4 districts and 25 oil companies use the same ocean-outfall, by mutual agreement only. About $1,000,000 has been spent to date, and the average daily discharge is 5,000,000 gal. The outfall is 25 miles long, including the ocean end of 3100 ft. discharging at 40-ft. depth. (See October 25th, 1927, issue for description.) There are two screening plants, the first built in 1924 and of the disk type. The second plant has Dorrco equipment. The plants are operated alternately, monthly. The sewage is very septic and the hydrogen sulphide gas was very offensive and also deteriorated the concrete pipe, manholes, etc., until in 1928-9 six W. & T. chlorinators were installed at different points. This was the first application in the country of chlorine for hydrogen sulphide control and has been very effective. (See 1928 C.S.W.A. Journal and various articles in "Western Construction News.") About 225 lb. of chlorine is used per day, which, nevertheless, is insufficient during the cannery season and hot weather. The screenings are stock-piled and hauled away by farmers.

W. T. Knowlton, sanitary engineer of the Bureau of Engineering, city of Los Angeles, enlisted support for the coming election in Los Angeles on a $6,000,000 bond issue for relief sewers, as much of the system is overtaxed; one reason being that each movie studio discharges from ½ to ¾ c.f.s., which is mostly clear water and will be reclaimed by the city.

Dinner Meeting, Pierpont Inn, Ventura—This meeting was attended by 120, including a number of the members' wives and several children.

B. J. Pardee, president, presided. In the absence of E. A. Reinke, Philip Schuyler acted as secretary. Music was furnished by the Poinsettia Trio through the courtesy of the Ventura Chamber of Commerce. John J. Wallace, secretary of the Chamber of Commerce, made a few remarks and was followed by Col. Miller, a newspaper editor from the eastern end of the county, who gave a humorous talk, including the definition of a "Scotchman as one whose impulses are under perfect control."

Philip Schuyler reported that publication of the 1930 Journal unfortunately had been delayed, but that it would be ready for mailing about April 16.

L. B. Reynolds read the report of the 1930 award committee, of which he is chairman, and presented the bronze plaque—the award of merit donated annually by Wallace & Tiernan Co., Inc.—to the Pasadena TriCities sewage treatment plant. Geo. K. Hooper, city engineer, acknowledged the award. The cash prize of $25.00—donated this year by Water Works Supply Co. ($10), Great Western Electro-Chemical Co., the Dorr Co., and N. Clark & Sons—was presented to A. W. Wyman, superintendent of the plant. In accepting this award, Wyman jocularly remarked that it would be a problem how to divide this $25.00 by 30, which is the total number of employees at the plant.

Alexander Bell, chairman of the membership committee, reported that 26 new members had been secured since the annual meeting in October, 1930; and urged that more effort be made to get city memberships, of which there are 19 to date.

It was unanimously voted to send E. A. Reinke, absent secretary, a telegram of congratulations upon the birth of a daughter and that suitable flowers be sent to his wife.

A paper on "My Experience with Ocean Outfalls," by C. L. Cooke, diver-inspector on the Hyperion ocean-outfall of the city of Los Angeles and the Santa Barbara ocean-outfall, was read by F. A. Batty of Los Angeles.

During the past seven years there have been a number of ocean-outfall sewers constructed along the coast of Southern California, from 6 to 84 in. diam. and from 1500 to 5400 ft. long, and of various materials such as wrought-iron, welded steel, cast-iron, and concrete. The wrought-iron pipe-lines, 6 to 18 in. diam., pulled to sea by tugs, proved the most economical to lay. The first consideration should be a careful survey and investigation of the ocean floor by a diver. A heavily ridged floor may indicate the presence of destructive rip tides; there may be unlooked-for obstructions, such as sunken craft; a heavy mud bottom may be impossible to drag a pipe-line through. If the weight of the pipe-line exceeds the weight of displaced water, it should be capped and pulled out full of air. Cooke recommends short lengths of heavy anchor chain for anchors, which soon become tightly imbedded in the sand, as preferable to concrete anchors. At the shore end the pipe-line should be laid below any possible scouring action.

The heavier and larger sizes of cast-iron and concrete present a problem for the designer and constructor. Cooke recommends investigation and consideration of the following eight items: (1) direction of tidal flow with reference to coast line; (2) maximum high and low

C. S. W. A. Third Spring Conference. (Upper Left) ***Open-Air*** *Meeting in Foster Park Amphitheatre. (Upper Right) Ventura Sewage Screening and Pumping Plant. (Lower Left) Carpinteria Sewage Pumping Plant, Under Construction. (Lower Right) Interior of Ventura Screening and Pumping Plant; Leon B. Reynolds at Right*

tides; (3) direction of predominating winds; (4) location and character of obstructions on ocean floor; (5) material to be excavated; (6) movement of shore-line during storms and high tides; (7) length of yearly storm period; (8) gradient of ocean floor.

The direction and speed of tidal flow and predominating winds controls movement of the sewage field and location of discharge end.

The Hyperion ocean-outfall, Los Angeles, is an 84-in. concrete pipe-line, 5400 ft. long, laid in 1924, in a trench 11 ft. deep, excavated by dredge bucket. As the line was parallel with tidal flow, no trouble was had in keeping trench open. The bottom of trench was very uneven and divers were used to cut down the humps, and a straight edge was used in laying the 4-pipe sections. The joints were made with a heavy bitumastic at 60° F. (air temperature), but many joints blew out when the sewage flow raised the temperature to 85° F. Divers had to cut manhole openings in pipe every 300 ft. and repaired the leaks with lead wool applied with chipping hammers.

The Santa Barbara ocean-outfall is 42 in. diam.; 3200 ft. long, and similar in design to the Hyperion, but the pipe sections were laid one at a time, and less trouble was had with the joints. The line, nevertheless, was plugged with sand three years ago. This sand was pumped from the sump in the pumping plant and quickly settled in the pipe-line when it came in contact with the heavier sea water during intermittent pumping; the pipe-line filling to within 8 in. of the crown. One of the manholes built into the pipe-line during construction, about 600 ft. from shore, was removed and the sewage allowed to flow out at this point; the pipe-line beyond clogging completely with sand. It proved a costly undertaking to clear this line and repair the joint leaks—taking 6 months' time. A collecting grit chamber has been installed at the pumping plant, to collect the great amount of sand in this system caused by the damage to the sewers during the earthquake of 1927. Intermittent pumping through ocean-outfalls should be avoided.

A. M. Rawn and Chester A. Smith followed with several interesting motion-picture reels on construction of ocean outfall sewers and treatment plants.

After the dinner, the Board of Directors met and discussed a "Sewer Rental" bill to be introduced in the State Legislature. This bill had been prepared by the Legislative Committee, J. C. Albers, chairman. Its approval was moved by A. K. Warren, seconded by Alexander Bell, and carried.

The directors met again at breakfast on Tuesday for an informal discussion of various matters.

Santa Paula Sewage Treatment Plant—The caravan formed at the Pierpont Inn, Ventura, on Tuesday morning, and proceeded to Santa Paula, where Harry E. Reddick, city engineer, described the plant. The first sewer system was built in 1911, mostly 6-in. sewers, discharging into a Cameron-type septic tank. By 1920, the sewers and tank were overloaded and conditions terrible. In 1923, a bond issue of $90,000 was voted and a new system constructed, consisting of a 20-in. outfall sewer, large intercepting sewers, a treatment plant, and sewer farm on a tract of 88 acres (cost $10,000), 25 acres of which are tillable —an all-gravity system.

The sewage of Santa Paula is largely domestic, with the addition of the wash water only from three citrus packing plants. An Imhoff tank was constructed at a cost of $16,330, in two units, each having sufficient capacity for the sewage from 5000 people. The present population is 7500, of which 80% is connected with the system; the average sewage flow being 300,000 g.p.d. The flowing-through chambers of the Imhoff tank are 52 ft. long, 6.25 ft. deep to the slot, with wall slopes of 1 to 1.4; the slots being 6 in. wide. The retention period is 3 hr. for average flow, and 2½ hr. for peak flow, which reaches the tank at 9 a. m. in fresh condition. The gas-vent area is 34.6% of the superficial area, and the freeboard 18 in. The sludge chambers are 18.7 ft. deep (below water level) with a bottom slope of 1 to 2; the total capacity being 18,080 cu. ft. or 3 cu. ft. per capita of present connected load, or 1.81 of ultimate.

The Imhoff tank was overtopped 11 ft. by the flood from the St. Francis dam, which failed in March, 1928, and the sand and debris, including 15 sewing machines, was cleaned out by the city of Los Angeles.

A new spreading ground has been made for the effluent, which is situated nearer the river and better isolated, consisting of 10 filter beds of ¼-acre area each, which are used in winter; the tenant on the sewer farm using the effluent for irrigation during the summer. The annual operating cost of the Imhoff tank is $500, and the city received $200 in return from the tenant for the effluent.

As a whole the Imhoff tank has functioned well, except for the usual periods of foaming, and one excessive period from November, 1930, to March, 1931. The scum was removed with a hog pump and allowed to dry out on the farm, and has since been used for fertilizer. Tests did not show anything radically wrong in the Imhoff tank; nevertheless the gas vents again overflowed, and the septic liquor tested pH 6.6 at its most acid conditions. Lime was added in one compartment, but only aggravated the foaming. It is possible that the cause was that the sludge level was too low, 8 to 12 ft. below slot level. No sludge has been drawn since, and it now stands 3½ ft. below slot level. Sulphur was also tried without effect on foaming. Reddick found each tank was operating at 50 to 60% of designed flow, and the entire flow was turned through one tank for a ten-day period and then alternated; immediate improvement being noticeable. The tanks are now cleaned twice a week, the walls being washed down; scum broken up and stirred; and a chain dragged the entire length of slots.

Twice a month pH determinations are taken, which at present are: city water, 7.4; influent, 7.9; effluent, 7.6; septic liquor, 6.8; sludge, 7.2. At present effluent is nearly clear, less than 0.1% by volume of solids settling out in 24 hr. There is some odor at this plant, which chlorination could help.

John Buck is superintendent of streets and sewers.

Ojai Sewage Treatment Plant—This plant was described by Alva J. Smith, of Black & Veatch, consulting engineers of Los Angeles and Kansas City, who remodeled and enlarged in 1929 a plant built in 1926. The present plant consists of prechlorination, an Imhoff tank converted into a plain settling tank, a separate gas-tight digester tank, sprinkling filter, secondary settling, sand beds, sludge drying beds, and burning of the gas from the digester.

The present connected population at Ojai is 1200, which at 55 gal. per capita gives an average daily flow of 66,000 gal. The alterations cost $12,000, or $10 per capita. The effluent from the sand beds, which is clear and free of suspended matter, is discharged into a nearby water course, without further chlorination.

Barbecue Lunch at Wheeler Springs—This resort is in a canyon above Ojai; and an excellent barbecue was served at $1 per plate. The success of the open-air meeting the previous day led B. J. Pardee, president, to hold the second day's meeting at Wheeler Springs, instead of in the Pierpont Inn, Ventura, as scheduled.

Leon B. Reynolds read the complete report of the 1930 Award of Merit committee. Moved by W. T. Knowlton, seconded by F. A. Batty, and carried, that it be adopted and placed on file.

A. K. Warren then moved the appointment of a continuing committee on annual Award of Merit of three members, to consist of the professors of sanitary engineering at Universities of California and Stanford and the chief engineer of the State Bureau of Sanitary Engineering. This was seconded by A. H. Koebig, Jr., and unanimously carried.

Harry E. Reddick then read a detailed paper on the Santa Paula sewage treatment plant previously inspected, and answered questions.

Philip Schuyler read the following resolution, which was adopted:

"Be it resolved that the thanks and appreciation of the California Sewage Works Association be extended to the following persons and firms for their efforts in helping to make the 1931 Spring Meeting at Ventura and environs a success.

"To the Ventura Chamber of Commerce, and especially John Largomarsino, president, and his associates for the wonderful Spanish Barbecue at Wren's Nest.

"To the City Council of Ventura.

"To the special committee on arrangements, consisting of D. C. McMillan, city engineer of Ventura, chairman; L. R. Walker, assistant city engineer of Santa Barbara; Harry E. Reddick, city engineer of Santa Paula; and A. L. Drown, mayor of Ojai.

"To Pacific Clay Products and Gladding, McBean & Co. for the membership badges and automobile number stickers.

"To Wallace & Tiernan Co., Inc., for Award of Merit plaque.

"To Water Works Supply Co.; Great Western Electro-Chemical Co.; N. Clark & Sons; and The Dorr Co. for the $25 cash prize awarded to A .W. Wyman, superintendent of the Pasadena Tri-Cities sewage treatment plant.

"To the California Highway Patrol for the motorcycle escort of the caravan."

Moved by Philip Schuyler and seconded by W. T. Knowlton that the secretary be instructed to mail a copy of this resolution to each of those enumerated.

The meeting then adjourned and the members departed in various directions, to meet again at the annual meeting September 21-24, at Del Monte, in conjunction with the League of California Municipalities.

C. S. W. A. Third Spring Conference

Registered Attendance

Albers, J. C., Glendale.
Allen, W. A., Pasadena
Arrasmith, C., Fillmore

Bamesburger, J. G., Santa Paula
Batty, F. A., Los Angeles
Beard, P. J., Stanford University
Bell, Alexander, San Francisco
Bennett, H. R., Los Angeles
Bennett, S. G., Oxnard
Bennett, S. M., Los Angeles
Bowers, Noble, Ventura
Baxall, Fred, Brea
Bravender, N. F., Los Angeles
Buck, J. H., Santa Paula
Burch, W. B., San Luis Obispo
Butler, Dr. F. O., Eldridge
Byxbee, Wm., Palo Alto
Byxbee, J. F., Palo Alto

Castello, W. O., Sacramento
Clarkson, E. H., Venice
Collins, A. P., Los Angeles
Crist, M. L., Los Angeles

Davies, Donald, Jr., Salinas
Drown, A. L., Ojai

Faulkner, J. D., Los Angeles
Ferguson, E. R., Eldridge
Fittinger, H., Santa Barbara
Freeman, V. M., Santa Paula
Froerer, Carl, Ventura

Galvin, T. E., Los Angeles
Gerstley, J., San Francisco
Giacomazzi, P. A., Santa Paula
Gillespie, C. G., Berkeley
Gillihan, Dr. A. F., San Luis Obispo
Goudey, Ray F., Los Angeles

Hansen, E. E., San Luis Obispo
Harmon, J. A., Los Angeles
Harmonson, V. P., Fillmore
Heinzman, Max, Ventura
Hooper, C. K., Pasadena
Hoskinson, C. M., Sacramento
Hutchinson, C. A., Colton

Imus, E. D., Oxnard
Irwin, L. W., Venice

Jacobson, John, U. C. Farm, Davis
Johnston, Fred L., Santa Barbara

Kaddy, J. L., San Diego
Kelly, E. M., Los Angeles
Klassen, R. A., South San Francisco
Knowlton, W. T., Los Angeles
Koebig, A. H. Jr., Los Angeles
Kohner, Max, Santa Clara

Lansingh, W. V., Santa Barbara
Loucks, R. L., Oceanside

Madsen, P. C., Pleasanton
McMillan, Donald C., Ventura
Meilandt, T. H., Ventura
Miller, Col. W. H., Fillmore
Moore, I. E., Los Angeles
Morgan, Geo. S., Los Angeles

Olsen, Ben, Palo Alto
Olsen, Louis, Palo Alto
Olson, L. F., Los Angeles

Palmer, H. K., Venice
Pardee, B. J., Visalia
Parkes, G. A., Los Angeles
Parsons, W. J., Los Angeles
Paulson, M. C., Los Angeles
Perry, Don E., San Anselmo
Phillips, W. B., Los Angeles
Pickard, A. B., Mayor, Pleasanton
Pierce, C. L., Glendale
Potter, H. B., Los Angeles
Prugh, J. I., Sacramento

Ramsey, W. L., Santa Paula
Rawn, A. M., Los Angeles
Reynolds, Leon B., Stanford University
Reddick, H. E., Santa Paula
Robinson, W. S., Los Angeles

Sarzatti, A., Ojai
Scherer, G. F., Ventura
Schuyler, Philip, San Francisco
Shook, H. E., San Francisco
Smith, Alva J., Pasadena
Smith, Chester A., Los Angeles
Smith, David, Santa Barbara
Soule, E. E., Ojai
Stedman, E. J., Santa Barbara
Steward, O. E., Anaheim
Stites, H. E., Burbank
Sinsheimer, L. F., San Luis Obispo

Tennant, Carl F., Long Beach

Vandewater, H. C., Glendale
Van Norman, J. H., El Segundo

Waggoner, E. R., Los Angeles
Walker, L. R., Santa Barbara
Warren, A. K., Los Angeles
West, Fred A., Stockton
Wilkie, F. A., Carlsbad
Wilsey, E. P., San Mateo
Wilson, Dr. Carl, Los Angeles
Wyman, A. W., Pasadena

Zuckweiler, G. C., San Diego

PROCEDURE FOR MAKING ANNUAL AWARD OF MERIT

The 1930 Award of Merit Committee, Leon B. Reynolds, chairman, reported at the Third Spring Conference, Ventura, on the following procedure to be used in determining the plant to which the annual award of merit shall be made:

A. **Considerations Involved**—The considerations involved in the decision, with their relative weights, shall be as follows:

a. Intelligent and conscientious operation 30%

b. Efficient results 30%

c. Ingenuity in method of operation, development of new devices, adaptation to local conditions 20%

d. Attractiveness and appearance of plant, sufficiency of support 20%

B. **Plants Considered**—During 3 out of 5 years the award shall be made to a plant producing a filtered or oxidized effluent, and during the remaining two years to a plant producing a screened or settled effluent. The award for each year of the 5-year period, beginning with 1930, shall be as follows:

a. First year, plant with filtered or oxidized effluent —

b. Second year, plant with screened or settled effluent —

c. Third year, plant with filtered or oxidized effluent —

d. Fourth year, plant with screened or settled effluent

e. Fifth year, plant with filtered or oxidized effluent

C. **Data to be Submitted to Committee**—The Award Committee, promptly after appointment, shall inform each eligible city, district, or institution as to the nature of the award, the time of the award, and the considerations involved in making the award. The committee shall furnish an entry blank to be returned by any city, district, or institution interested in the award, and may also require the submission of pertinent data regarding the operation of the plant.

D. **Time of Award**—The Award Committee, appointed by the directors after each annual meeting, shall make its report and the award shall be presented at the annual meeting held the following fall.

PROGRAM FOURTH ANNUAL MEETING
SEPTEMBER 21-22, 1931

Headquarters: Del Monte Hotel, Monterey
Local Committee: Howard Cozzens, Chairman;
T. R. Haseltine and D. D. Davies.

MONDAY, SEPTEMBER 21

8 a. m.....Meet at City Hall, Salinas

8-8:45—Visit cannery treatment plant and sewage pumps in town.

9-10 —Visit beet sugar plant and waste disposal at Spreckels.

10:15-11:30—Visit Salinas sewage disposal plant.

Noon—Luncheon at Rock Quarry near Watsonville. Guests of Granite Rock Company.

2-3:00—Visit Watsonville Water Works. Talk on beautification by H. A. Hyde, landscape architect.

3:30-4:30 p. m.—Visit Watsonville screening plant. Return to Monterey.

7:00—Dinner. Talks by C. C. Kennedy, W. A. Allen, Dr. Carl Wilson and Dr. A. J. Fischer on "Sewage Disposal Out of California."

TUESDAY, SEPTEMBER 22

9-10 a. m.—Business meeting and election of officers.
Committee reports.

10-11:30—Papers on Operation—with discussions.

(1) Progress at Salinas. T. R. Haseltine.

(2) Progress at Griffith Park, Los Angeles Water Department. R. F. Goudey.

(3) Operation of Typical Sewage Disposal Plants in California. E. A. Reinke.

11:30-12—General discussion—manholes, sewer flushing, joints, etc.

Noon—Luncheon. Talk by J. P. Sandholdt, Mayor, Monterey.

2-5 p. m.—Joint meeting with Engineers' Section of League of California Municipalities.

Papers:

Relation of Sewage Works Operator to State Department of Public Health. Giles S. Porter, M. D.

New Activated Sludge Plant at Yosemite. H. B. Hommon.

Sewer Ventilation, Why and How? David Donaldson.

What's New in Sewer Pipe Manufacture. A. W. Rawn.

Odor Control of Fish Canneries. H. D. Severance, City Engineer, Monterey.

Legal and Other Considerations on Sewer Rentals. W. J. Locke, Secretary-Manager, League of California Municipalities.

CALIFORNIA SEWAGE WORKS ASSOCIATION

Fourth Annual Convention at Monterey September 21 and 22—Inspection Trips—New Officers—Attendance—Papers and Discussions.

Nearly 120 delegates and guests attended the fourth annual convention of the California Sewage Works Association at Monterey, September 21 and 22. The program included inspection trips, informal after-dinner talks, a business meeting with election of officers, a number of excellent papers on sewage treatment plant design and operation, and round-table discussions. The registered attendance was as follows:

C.S.W.A. Fourth Annual Meeting

Albers, J. C., city engineer, Glendale, and Mrs. Albers.
Allen, Wm. A., assist. supt., sewage plant, Pasadena.
Askew, W. L., sewer supt., Carmel.
Baldwin, Arnold, surveyor, Santa Cruz.
Batty, F. A., sewer maint. engineer, Los Angeles, and Mrs. Batty.
Beale, A. W., sanitary inspector, San Diego.
Bell, Alexander, Pac. coast manager, Wallace & Tiernan Co., San Francisco.
Bennett, S. M., operator, Griffith Park plant, Los Angeles.
Beyer, A. C., district mgr., Wallace & Tiernan Co., San Francisco.
Blakely, J. F., city clerk, Lodi.
Blood, Chas. R., assist. city engineer, Sacramento.
Blumberg, Oscar, operator, Chenery filtration plant, Clyde.
Bothwell, Bruce, assist. city engineer, San Jose.
Bowen, M. R., city engineer, Whittier.
Brennen, B., city attorney, Glendale.
Butler, Dr., supt., Sonoma State Home, Eldridge.
Byxbee, J. F., city engineer, Palo Alto, and Mrs. Byxbee.
Callaghan, D. A., alderman, Watsonville.
Castello, W. O., supt. of sewers, Sacramento.
Christensen, Mrs. M. L., secy., North Palo Alto Sanitary District.
Clark, A. A., California Assoc. Concrete Pipe Manufacturers.
Cozzens, H. F., city engineer, Salinas.
Crist, Marion L., assoc. engineer, Burns-McDonnell-Smith Engineering Co., Los Angeles.
Darwin, A. G., assist. editor, "Western Construction News," San Francisco.
Davies, Donald Jr., assist. city engineer, Salinas.
Davies, William, member, Cozzens & Davies, engineers, Salinas.
Davis, Sam, councilman, Glendale, and Mrs. Davis.
DeCosta, J. D., sanitary engineer, E.B.M.U.D., Oakland.
Drown, A. L., mayor, Ojai.
Eastman, T. F., sewer engineer, city engineer's office, Oakland.
Ferguson, E. R., engineer, Sonoma State Home, Eldridge.
Fischer, A. J., research engineer, Dorr Co., New York, and Mrs. Fischer.
Galeria, R. H., street supt., Atwater.
Gillespie, C. G., chief, Bur. Sanitary Eng., Berkeley.
Gilpin, B. E., deputy city engineer, Phoenix, Arizona.
Gladding, A. L., Gladding Bros., San Jose.
Gladding, A. C., Gladding Bros., San Jose.
Goodridge, Harry, city engineer, Berkeley.
Goudey, R. F., sanitary engineer, Los Angeles Bur. Water Works & Supply.
Gray, Harold F., consulting sanitary engineer, Berkeley.
Hall, Horace C., city engineer, Turlock, and Mrs. Hall.
Hammerly, F. V., sales engineer, Water Works Supply Co., San Francisco.
Hansen, E. E., sanitary inspector, San Luis Obispo .
Harmon, Judson A., assist. engineer, Bur. Sanitary Eng., Los Angeles.
Haseltine, T. R., sewage treatment plant supt., Salinas .
Heinzman, Max, sanitary inspector, Ventura.
Holfelder, J., city engineer, Bakersfield.
Hommon, H. B., sanitary engineer, U. S. Pub. Health Service, San Francisco.
Hoskinson, Carl M., chief pumping plant operator, Sacramento.
Houck, C. P., chief plumber, Yosemite Park, and Mrs. Houck.
Hyde, Charles Gilman, prof. sanitary engineering, Univ. of Cal.
Hyde, H. A., landscape gardener, Watsonville.
Jacobson, John, supt. const., U. C. Farm, Davis, and Mrs. Jacobson.
Jenks, Harry N., consulting sanitary engineer, Berkeley.
Jensen, Andrew M., Clay Products Institute, San Francisco.
Jewell, H. W., Pacific Clay Products Co., Los Angeles.
Kelch, Norman, secy., Clay Products Institute of Calif., Los Angeles.
Kelly, Earl M., engineer, Dorr Co., Los Angeles.
Kennedy, Clyde C., consulting municipal engineer, San Francisco.
Kitchen, H. B., city engineer, Watsonville.

Kivari, A. M., Pac. coast manager, Dorr Co., Los Angeles.
Kjellberg, G., supt. of sewers, Riverside.
Knowlton, W. T., sanitary engineer, sewer dept., Los Angeles.
Koebig, A. H. Jr., cons. engineer, Koebig & Koebig, Los Angeles.
Lauridsen, Karl, California State Highway Patrol.
Lee, Charles H., consulting engineer, San Francisco.
Linton, Robert, pres., Pacific Clay Products Co., Los Angeles.
Locke, Wm. J., secy.-mgr., League Calif. Mun., San Francisco.
Mason, John L., Water Works Supply Co., San Francisco.
McMillan, Donald C., city engineer, Ventura.
Meneray, Dr., county health officer, Santa Rosa.
Morris, H. R.
Mushen, S. A., city engineer, Alturas.
Pardee, B. J., city manager, Visalia.
Paterson, Agnes E., public stenographer, Palo Alto.
Perry, Don E., manager, sanitary district, San Anselmo.
Phillips, Wm. B., Gladding, McBean & Co., Los Angeles.
Polich, T. P., pres., United Concrete Pipe Co., Los Angeles.
Polk, Martin C., city engineer, Chico.
Popp, W. L., city engineer, San Jose.
Porter, Giles S., dir., State Dept. Public Health, Sacramento.
Prior, Guy R., Riverside.
Ralston, C. P., mayor, Atwater.
Rawn, A. M., asst. chief engineer, L. A. County Sanitation Districts.
Rea, Charles, engineer, Burlingame.
Reeve, J. E., sewage plant operator, Salinas.
Reinke, E. A., sr. san. engineer, Bureau Sanitary Eng., Berkeley.
Reinoehl, D. E., engineer with C. C. Kennedy, San Francisco.
Reynolds, Leon B., prof. sanitary engineering, Stanford University.
Ribal, Raymond R., office engineer, city engineer's office, Oakland.
Roberts, W. C., dir., Pacific Engineering Laboratory, San Francisco.
Rockwell, Johanne, councilwoman, Carmel.
Rogers, Karl R., vice-pres., Montezuma Mountain School, Los Gatos.
Severance, Howard D., city engineer, Monterey.
Shattuck, J. George, engineer, city engineer's office, Palo Alto.
Sherman, W. R., surveyor and irrigation engineer, Newman.
Silva, M., alderman, Watsonville.
Sloan, Charles E., consulting engineer, San Francisco.
Smith, J. F., sales mgr., Gt. Western Electro-Chemical Co., San Francisco.
Spencer, John, engineer, State Fish and Game Commission, San Francisco.
Stevenson, Ralph, san. engineer, Gt. Western Electro-Chemical Co.
Stites, H. I., city engineer, Burbank.
Taylor, C. C., city engineer, Sparks, Nevada.
Van Norman, J. H., chief screening plant operator, El Segundo.
Waggoner, E. R., Pacific Clay Products Co., Los Angeles.
West, Fred A., engineer disposal plant, Stockton, and Mrs. West.
Wilson, Carl, lab. director, L. A. Bureau of Water Works & Supply.
Wilson, Jeff, Granite Rock Co., Watsonville, and Mrs. Wilson.
Wintersgill, A. T., sales mgr., Pacific Clay Products Co., Los Angeles.

INSPECTION TRIPS

The convention opened with an impromptu breakfast at Salinas on September 21, followed by assembly at the City Hall and a conducted caravan to the $10,000 cannery waste pre-treatment and pumping plant, operated by the city. This plant serves a cannery with a daily capacity of 120 tons, which handles pears, apricots, peaches, spinach, tomatoes, and artichokes, each in its particular season. Some of the wastes are susceptible to screening, others to sedimentation, and still others to chemical precipitation. A 3 by 3-ft. self-cleansing, drum-type sewage screen has been installed at the plant, followed by a 20-ft. circular clarifier, with mechanism for sludge removal. Provision is made for by-passing the screen and for measuring screenings and settled sludge. Liquid wastes are pumped to the city storm sewer and discharged onto a 20-acre natural-sand filter at the river. Sludge and screenings are hauled to the garbage dump. The average flow of cannery wastes is 250 g.p.m., and the plant operates only during the canning season. Peaches and tomatoes are the hardest fruits to handle, spinach being the least troublesome waste treated.

The beet-sugar plant and waste disposal system of the Spreckels Sugar Co., at Spreckels, near Salinas, was next inspected. The sugar

plant has an average production of 4000 tons of beets per 24-hour day, 2 shifts, operating 100 days per year, and in the maximum day of record handled 5016 tons. The beets yield about 19 per cent sugar, molasses residue being used with the dried pulp to make cattle feed. Beets are delivered from the Sacramento valley by trainloads, dumped into storage sheds, fed to flumes which lead to screw conveyors at the mill, being washed and scrubbed during the fluming process. Hot condenser-water from the boiler room is used in the flume. The plant produces 14,000 sacks (100-lb.) of sugar and 4500 bags (100-lb.) of dried pulp daily. Waste water is ponded and passed through natural-sand filters along the Salinas river, using a 55-acre regulating basin and 300 acres of ponds. The plant requires a water supply of 2000 g.p.m., secured from private wells.

The C.S.W.A. caravan next visited the new Salinas sewage treatment plant, combining separate sludge digestion with the activated sludge process. (For details of design and operation of this plant see the September 25th, 1930, and September 10th, 1931, issues of Western Construction News.)

Luncheon, attendance 100, was held at the rock quarry of the Granite Rock Co. at Aromas, near Watsonville, as guests of the company, followed by an inspection of the quarry and the crushing and screening plants. This quarry, which has been operating since 1909, lies along the great San Andreas fault, and the country rock has been well shattered by earthquake disturbance.

The new slow-sand filtration plant of the Watsonville water works at Corrallitos village was then visited. The grounds of this plant have been made highly attractive by landscaping, and the aerator has been constructed in the form of a rock garden. H. A. Hyde made a short talk on the beautification of this plant.

A dinner meeting was held at Monterey, attendance 71. Four informal talks were given on "Sewage Disposal Out of California," the speakers being Clyde C. Kennedy, A. J. Fischer, Carl Wilson and W. A. Allen. Each of these men had made an extended inspection of treatment plants in the east and middle west, and the symposium presented four distinct and interesting viewpoints—that of a consulting engineer on design, research man on methods of treatment and application of mechanical equipment, laboratory director, and plant operator. Wilson stressed the related interests ofthe sewage plant operator and the water works man, calling sewage the "alpha" and "omega" of water supply; he also showed a number of slides of plants visited. These talks, together with the formal papers described hereafter, will be abstracted in an early issue.

BUSINESS AND TECHNICAL SESSIONS, SEPTEMBER 22

A directors' breakfast meeting was called for 7 a. m. on July 22, at which time it was decided to hold the fourth annual spring conference at Yosemite, probably during May. The business meeting opened at 9 a. m., President B. J. Pardee presiding.

Committee Reports

Membership Committee—J. A. Harmon reported 237 members in 1931, showing an increase of 11 over 1930. The following percentages between the different groups were given:

City, county, or state	36%
Consulting	17%
Operators and inspectors	16%
Commercial, main	17%
Administrators	5%
Laboratory	3%
Miscellaneous	6%

Standard Report Form—A. M. Rawn reported no progress in this connection for the present year. He stated that two previous forms were published last year and discussed at the last annual meeting. He advocated a shorter form and urged the trial and use of forms already prepared.

Editorial Committee—E. A. Reinke cited that the usual publicity work had been accomplished through the publication of the journal. He announced that the editorial committee had also been made the program committee, and had planned the program for the present meeting. Suggestions on the part of members were welcomed.

Publicity Committee—In the absence of Philip Schuyler this report was omitted.

Legislative Committee—J. C. Albers announced that his committee is at the present working on proposed legislation to come before the next Legislature. No report was given at this time.

Nomination Committee—E. A. Reinke stated that inasmuch as the regular nominating committee had been 100% absent at the morning session held by the Board of Directors, the following nominations were declared by the board as a whole for officers for the ensuing year:

President—The present vice-president, W. A. Allen.
First Vice-President—The present second vice-president, John Jacobson.
Second Vice-President—D. McMillan, Ventura; Fred West, Stockton.
Board of Directors (5-year term)—L. Reynolds, Stanford University.
Board of Control (2-year term)—C. G. Hyde, Berkeley.

Motion to Cast Ballot—Motion was made by A. M. Rawn, seconded, and duly carried that with the exception of the second vice-president, the secretary be instructed to cast the regular ballot for all officers nominated. The following vote was obtained for second vice-president:

D. McMillan	21
Fred West	15

Election of Secretary-Treasurer—E. A. Reinke was unanimously elected to the office of secretary-treasurer for the coming year.

An Auditing Committee, consisting of Leon B. Reynolds and C. G. Hyde, was appointed by the chairman to make the annual audit of the treasurer's books. This was done during the course of the meeting, and the books were passed as being correct.

Wire to Philip Schuyler—The suggestion was made by C. G. Gillespie that a wire be sent to Philip Schuyler, who is at the present time at Las Vegas, due to illness. The secretary was so instructed.

Adjournment of Business Meeting—There being no further business to transact, a discussion period was declared in order, preliminary to the rendering of the various reports at the 10 o'clock session.

Discussion of Papers

A. M. Rawn favored a discussion of the papers read at the banquet session on September 21. He called particular attention to A. J. Fischer's report concerning the efficacy of sludge agitation in increasing the production of gas. Rawn stated that he had read with some interest the result of experimental work performed in Germany along this line, and from this source, he affirmed, comes the chief contention that stirring is of no particular value in sludge digestion. Prominent eastern engineers have likewise placed no particular importance upon the value of agitation, he stated.

Fischer replied that experimental tests carried on within the last month have indicated conclusively that stirring increases gas production. A series of tests have been conducted at Aurora, Illinois, he stated, showing an approximate increase of 10% in gas production where stirring is used. Ultimately, of course, the same amount of gas will result in either case, but over a considerably longer period of time. More gas is actually produced through short-time digestion. Supernatant liquor is eliminated as a result of violent agitation. The carbon dioxide yield is slightly higher—approximately 2 or 3%. In both instances where stirring was used in conducting the three tests at Aurora there was actually a 10% increase in gas yield, he informed.

Rawn stated further that while his personal opinion was inclined to be in accord with that of Fischer, he must recognize the conclusions of the Committee of Sanitation Engineers of the American Society of Mechanical Engineers, which states that although, in general, stirring produces a more uniform flow and therefore a more adequate control of sludge digestion due to easier disposal of by-products, the point of gas increase is one which has not been definitely established.

T. R. Haseltine further enlarged upon the subject of gas increase by means of stirring, with the following comments:

When the digester at the Salinas plant was stirred, 200 cu. ft. of gas per day built up to 15,000 cu. ft. This experiment was conducted from October 8 to the middle of May. Gas production varied from day to day and was low all the time. The plant was equipped for recirculation of sludge and sludge was recirculated for one day, at which time a marked increase of gas resulted. This would fall down and then come back. When the pH got up to 7 and stabilization was reached, no effect on gas production was noted, in contrast to the very marked effect when stirring was first started in the digester.

Remarks concerning elimination of scum by recirculation:

R. F. Goudey—Instead of recirculating sludge, circulate supernatant liquor over the scum.

John L. Mason—Many plants in the east have been built, where a number of sludge-sampling tubes have been installed on the sides of the sludge tanks.

W. A. Allen—Capacity seems to be lower than it is generally necessary to build. He stated that there might be discussion on that point.

Mason—In several eastern states there are a number of plants which limit the capacity of Imhoff tanks, or any sludge digestion tank, where 3 cu. ft. per capita cannot be built.

Fischer—The State Board of Health in New York requires proof in figures before permission will be granted to do this.

Low capacity for digester—In accordance with data collected from the Grand Rapids plant, sludge is being digested in 20 days in main digester and stirred in stirring tanks until it can be let onto the sludge beds (9½% solids). Organic load for that plant is 6.6 cu. ft. per lb. of volatile matter per day. No trouble was experienced in digesting sludge in less than 20 days.

Grand Rapids sludge runs about 80 to 85% moisture and is pumped until it reaches 95 or 96%. The South Dakota plant pumped 8 hr. per day and had solid concentration of 35% at the beginning of pumping, continuing 10% over entire day.

Goudey commented upon factors determining the thickness of sludge in the east, enumerating them as follows:

1. Presence of large quantities of grit.
2. Lower temperature.
3. Presence of greater amount of mineral.

There is no comparison in the size of grit chambers in plants in eastern states and those of the west, he stated. The south has practically the same type of sludge that we have here.

Reinke stated that despite his observations he had never yet seen a definition (which meant anything) as to what digested sludge is. He requested a definition of Fischer. The latter replied (humorously) that "if you can draw a sludge out of a tank that is inoffensive, it is digested".

Reinke further questioned Fischer as to the results of experiments conducted at Salem, Ohio, who replied that "Observations at Salem on waste of excess activated sludge to primary clarifier coincided with observations at Los Angeles. When waste activated sludge was returned to the primary clarifier, an average solid content of 9½% was obtained, whereas when the activated sludge was pumped directly to the digester the average solid content was between 2 and 3%. Experience with the paddle aerator at this plant showed that a satisfactory effluent could be produced using 0.3 cu. ft. of air per gal. or less, as against 1 cu. ft. per gal. with plain spiral-flow aeration."

Reports

The following reports were then submitted:

I. Salinas Sewage Treatment Plant—T. R. Haseltine-Crist.

II. Progress at Griffith Park, Los Angeles Water Department, R. F. Goudey-Haseltine, Crist and Fischer.

III. Operation of Typical Sewage Disposal Plants in California—E. A. Reinke-Haseltine, Goudey and Fischer.

In the general discussion which followed, comments were made by Clyde C. Kennedy upon the proper disposal of overflow liquor, comparing the methods cited in reports given previously by Fischer and Goudey.

Joints—Don E. Perry, representing Sanitary District No. 1, Marin County, spoke briefly upon the difficulty experienced in his district through the use of Petrolastic joints which, he stated, have not proved effective in keeping out roots.

Goudey explained that frequently air-blown asphalt is penetrated by roots due to the microscopic air bubbles, which permit of plant life.

Norman W. Kelch, secretary-manager of the Clay Products Institute of California, reported the following progress in connection with the development of a root-proof joint, now being brought about by his Institute. He stated that they have been working upon the development of a compound which will be successful in point of root penetration. He continued: "Any such compound would necessarily have to have the following properties:

1. Must be water-tight.
2. Must stick to pipe.
3. Must have flexibility to line.
4. Must keep out roots.

"In making an asphalt joint, better grades are used. 'Petrolastic' is a term which has been misused to indicate bituminous or asphaltic compounds. Therefore, when a petrolastic joint, which was developed by the Standard Oil Co., was put out, this compound contained a filter. Unfortunately, contractors have substituted common roof asphalt at perhaps ¼ or ½ less cost. Those joints which were made up of cheaper asphalts are responsible for the reputation which has come to some joints which have short-root penetration. We have been trying to get down to a point where we can definitely determine certain limiting points of penetration with certain types of filters. Some compounds have been developed which can be taken apart and put together with different types of materials, so it will not be an exclusively patented substance. The process employed in manufacturing compounds is similar to that of varnish; the secret of success lies in adding the various materials at the proper time, as well as in the manner of manufacture. A compound might answer the general specifications in every detail—melting point, penetration, percentage of filter—and yet might not be carefully enough made. We are endeavoring to include a germicide in the compound which is at present being investigated. So far we have developed a compound which has been successful in keeping out roots indefinitely; information concerning it will be made public within the near future."

Adjournment—The reports having been read and subsequently discussed, adjournment was called at 12 noon, until the afternoon session.

Reports at Combined Meeting

The afternoon meeting was held with the central section of the League of California Municipalities, then in convention at Monterey. Charles R. Blood opened the combined meeting, afterward turning it over to B. J. Pardee.

Giles S. Porter, director, California State Department of Public Health, gave a paper on the "Relation of Sewage Works Operators to the Department of Public Health"; pledging the help of his organiza-

tion in conducting operators' schools and providing an increased personnel in the State Bureau of Sanitary Engineering. C. C. Kennedy suggested that plant inspection be made a routine and that monthly reports should be required of superintendents—both being means to increase the efficiency of operation and upkeep of plants. Harold F. Gray outlined the previous failures to secure full support from the State Department of Public Health for activities of the C.S.W.A., and urged better cooperation from the present organization. Don E. Perry stated that public interest in sewerage systems could not be secured until an odor nuisance arose. He urged that the tax rate for support of sanitation districts should be raised.

H. B. Hommon described the "New Activated Sludge Plant at Yosemite". The contributing population in Yosemite valley (tourist) has increased from 33,452 in 1915 to 490,000 in 1927, and 458,500 in 1930, with a 3-day peak population of 28,400 at the close of May, 1927. The sewage flow varies from 200,000 to 900,000 g.p.d. Yosemite valley is 7 miles long by an average of 1 mile wide, steep-walled on the north and south sides, with the river in the center and highways on each side. Odors settle down in the valley and offer a serious problem to sewage treatment plant design and operation in this popular vacation park. A treatment plant has just been completed ¾-mile east of Bridal Veil Falls, on the south side of the valley, which is in the shade from December to March of each year. Four miles of sewer lines have been laid. Operation of the plant started August 8 and data are now being collected.

A paper by David Donaldson, Alhambra, on "Sewer Ventilation," was read by F. A. Batty. This paper was discussed by Albers, Crist, Batty, Knowlton, Hyde, Gillespie and Rawn, as regards safety lamps, gas masks and prevention of explosions. An additional paper on the subject was introduced by Knowlton.

A. M. Rawn reported on "What Is New in Sewer Pipe Manufacture" (see paper elsewhere in this issue). T. F. Eastman stressed the need of cooperation among engineers of various sewer departments and manufacturers to secure a uniform specification for various classes of pipe. The inertia of contractors toward new methods in trench construction was brought out. Other discussion was by Carl Hoskinson, Charles Lee and H. F. Jewell.

Howard D. Severance, city engineer of Monterey, in a most humorous paper, discussed the "Odor Control of Fish Canneries," or, more properly, the "Control of Monterey by Fish Odors." Burning of fish meal has caused much distress in Monterey and various ordinances have been passed to reduce the offensive odors. However, "the enforcement of any law depends on where the center of gravity of public opinion lies."

W. T. Knowlton presented resolutions for the resolutions committee.

W. J. Locke, secretary-manager of the League of California Municipalities, gave some "Legal and Other Considerations on Sewer Rentals," his paper being discussed by Mrs. Christensen, Don E. Perry and others. Thereafter the convention adjourned.

AERATION EXPERIMENTS AND EXPERIENCES AT SALINAS, CALIFORNIA

By T. R. HASELTINE*

The Salinas sewage treatment plant, which has been in operation 16 months, combines separate sludge digestion with the activated sludge process. I have just written two papers on the plant; one which deals with our experience in the concentration and digestion of activated sludge will appear in the next issue of "Sewage Works Journal"; the other, which gave complete results obtained, and operating costs, during the first year, was published in the September 10th, 1931, issue of "Western Construction News." Because these articles are both available to you and because operating troubles are often more interesting than results, I will summarize the results as rapidly as possible and then tell you something of our troubles.

The Salinas sewage is extremely strong and difficult to treat. It has 490 p.p.m. 5-day B.O.D., 360 p.p.m. suspended solids, 65 p.p.m. ammonia plus organic nitrogen, and 200 p.p.m. ether-soluble matter. Primary sedimentation removes 52% of the suspended matter, 27% of the B.O.D. and ether-soluble matter, and 13% of the organic plus ammonia nitrogen. The activated sludge process effects further purification, so that the entire plant removes 94% of the suspended matter and B.O.D. and 64% of the ammonia plus organic nitrogen on an average, although the final effluent varies over wide limits. Specifically relative stabilities range from 11 to 99% and nitrates from 0.0 to 16.5 p.p.m.

At the present time, because of limited blower capacity, air is supplied at a uniform rate. The sludge deteriorates markedly through the day, but is usually rejuvenated during the night. Occasionally, too, serious bulking occurs, and at such times by-passing part of the flow to sand beds at the river is the only effective way of overcoming the difficulty. It is believed that if the rate of aeration could be varied with the sewage flow that the average quality of the effluent could be improved and the wide fluctuations in its quality as well as some of the bulking could be decreased.

The excess activated sludge is concentrated by combining it with the crude sewage. The primary activated sludge mixture removed from the preliminary clarifier is then digested. About 12,000 cu. ft. of gas (heating value 650 b.t.u. per cu. ft.) is collected daily. Calculations show that if this gas were utilized in a gas engine, sufficient power could be developed to supply the additional air needed and at the same time effect an annual saving of $600 over the present operating costs. However, at times this gas has contained considerable hydrogen sulphide, which is corrosive to an internal combustion engine. At the present time we are endeavoring to determine the cause of the hydrogen sulphide formation, the best means of eliminating it, and how much

*Sewage Treatment Plant Operator, Salinas.

can be present without seriously affecting the engine. For that purpose we are operating a Ford engine on the gas and making periodical examinations of its condition. This work has not progressed far enough to have any results to give you at this time.

The digested sludge, after being dried on sand beds, is sold as fertilizer. The city of Salinas has recently contracted the entire output to a buyer who pays $20 per bed for the sludge and removes it from the beds himself. Each bed is 50 ft. by 62.5 ft. in plan.

The extraordinary strength of the sewage has caused considerable difficulty in the aeration process. The first trouble encountered was in building up an activated sludge. After several attempts it was found to be impossible to build up a good sludge with a continuous flow through the tanks, so it was necessary to operate on a fill-and-draw schedule until sufficient well-aerated sludge was accumulated. The next difficulty was a frequent bulking of the sludge, which made it impossible to treat the entire flow satisfactorily. Increasing the return-sludge capacity and adopting the practice of sludge reaeration by some slight piping changes has eliminated this trouble to a large extent and made possible the previously stated results. While these difficulties were directly attributable to the extremely strong sewage, they caused us to give our aeration methods critical study. Some experiments were run which I believe may be of interest to you in spite of the crude methods employed in conducting them.

Design of Aerators—As you who visited the plant yesterday know, there are two spiral-flow aeration tanks operated in parallel. Each tank is 24 ft. wide, 64 ft. long and 12 ft. deep, with a baffle extending 56 ft. along the center of the tank, around which the sewage flows. The combined capacity of the two tanks is 33,740 cu. ft. Air is introduced through two rows of filtros plates along each side of the center baffle at 5.6 lb. per sq. in. pressure. The plates form the roof of air ducts cast in the floor. Each row, which contains 40 plates, is controlled by a single valve at the inlet end. Fig. 1 shows a cross-section of one of the tanks. The return-sludge enters at one end of each tank, while the settled sewage is introduced three-eighths of the way down one side. Thus, about 19% of the tank capacity is used for sludge reaeration.

It will be noted that the Salinas tanks differ from the original spiral-flow tanks at Indianapolis, and from most such tanks built since then, in that the flowing-through channel has the same width as it has depth, while in most tanks the channel is wider than it is deep. This departure is illustrative of one of the difficulties encountered in designing a small plant. It is generally conceded that deep tanks give greater economy and efficiency than shallow ones, therefore a depth of 12 ft. was decided upon as the first dimension. It is also agreed that the tanks should be as long as possible to minimize the possibility of short circuiting, therefore, the tanks were narrowed down to gain length. At the time of designing, it was thought that this decreased width would simply be an aid to setting up a spiral flow, but, as will be shown later, the circulatory motion proved to be too perfect under the operating conditions.

Operation of Aerators—Due to the abnormal strength of the Salinas sewage, we had some difficulty in maintaining a sufficient supply of dissolved oxygen in the aeration tanks. On some occasions the mixed liquor would flow half-way through the tanks before obtaining an oxygen content of more than 0.1 to 0.3 p.p.m. as determined after 20 min. standing in stoppered bottles to permit settling out of the floc. It was found that, by using considerably more air in the inlet sides of the tanks than was used in the outlet sides, the average dissolved oxygen content of the tanks could be decidedly increased. For that reason and because it was considered desirable to use plenty of air in the sludge reaeration chamber, it is now standard practice at Salinas

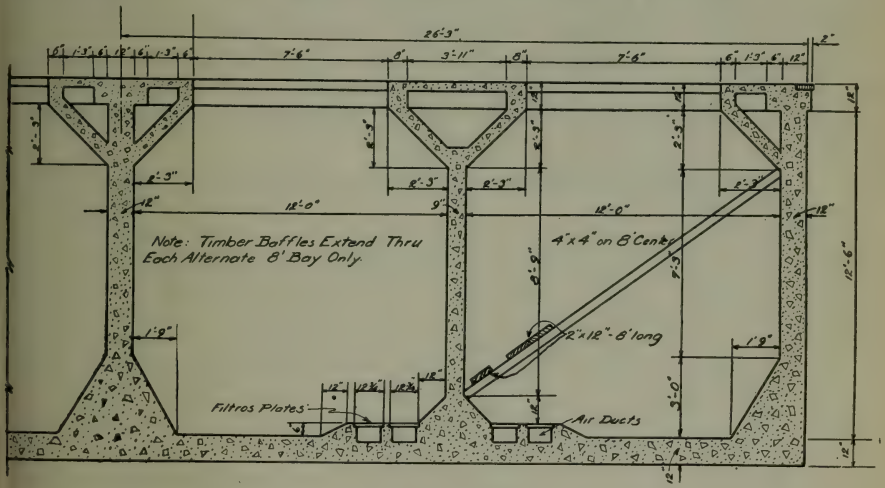

Fig. 1. Cross-Section of Spiral-Flow Aeration Tank

to use 60 to 70% of the air in the inlet sides of the aeration tanks.

Air consumption is high at Salinas due to the strong sewage; an average of 2.0 cu. ft. per gal. of sewage being used. Because of this high consumption and the aforementioned unequal air distribution, rates of aeration as high as 4 cu. ft. per sq. ft. of plate area are used. It was thought that at this high rate the air bubbles might be passing through the liquor too rapidly to permit the maximum absorption of their contained oxygen. The turbulent appearance of the tank surface made this difficulty seem quite probable.

Another thought was the possibility of a central core existing in the aeration tanks, in which the liquor came in contact with very little air, and that if such a core was present, a considerable portion of the sewage could pass through the tanks in a much shorter length of time than the theoretical aeration period. Dissolved oxygen and ammonia nitrogen determinations taken at different points in the tank cross-section neither proved nor disproved the existence of such a core, so it was decided to determine the actual detention period in the aeration tanks. The addition of a dye that would be unaffected by the sludge or a chemical such as common salt to the entering sewage would probably have been the most accurate way of determining the aeration period,

but, because of the large amount of the indicator required and its possible deleterious effect on the sludge, it was decided to use matches instead. Consequently a large box of new matches was emptied into the settled sewage as it left the primary settler, and the time required for the matches to pass through the aeration tanks and to appear floating on the water surface in back of the baffles at the inlets of the final clarifiers was noted. Table I gives the results of this test. The theoretical detention period at the time of making the test was 7.4 hr. Obviously, many matches became lodged in the grease scum on the sides of the aeration tanks or collected in the corner at the far end of the tanks because of their inability to get through the wall of rising air at the end of the center baffle. Therefore, the actual aeration period was probably considerably shorter than this test indicated. The test was interpreted as showing that some of the sewage passed through the tanks very rapidly and that the actual aeration period was probably about 6 hr., or 80% of the theoretical period.

TABLE I

Time Required for Matches to Pass Through Aeration Tanks

No. Matches Passing	Time Req. for Passage, Hr.
3	1.3 to 1.5
1	1.5 to 2.3
4	2.3 to 2.8
4	2.8 to 3.3
11	3.3 to 4.3
4	4.3 to 5.3
39	5.3 to 6.3
18	6.3 to 7.3
18	7.3 to 8.3
12	8.3 to 9.3
15	9.3 to 10.3
15	10.3 to 11.3
15	11.3 to 12.3
8	12.3 to 13.3
3	13.3 to 14.3

Aeration Experiments—As a result of this study, some baffles were placed in one aeration tank last February as an experiment. These baffles are shown in Fig. 1. They consist of two 2 by 12-in. planks 8 ft. long, placed on an angle of about 45 deg. over the filtros plates and about 2 ft. above them. The baffles were so placed as to permit part of the air to pass directly upward and so maintain the spiral flow of the mixed liquor, while the remaining air was deflected out toward the center of the tank to break up any central core through which the sewage might be short circuiting. At the same time, it was hoped some of the air bubbles would be caused to remain in contact with the liquor for a longer period, thereby permitting more oxygen to be absorbed. The baffles, as placed, were not continuous throughout the length of the tank; on the contrary, each alternate 8-ft. length was baffled while the intervening spaces remained unbaffled.

The first effect of the baffles to be noticed was the changed appearance on the surfaces of the tanks. In the unbaffled tank the air appeared to come up with a boiling action over the plates, and the spiral flow set up was so rapid that hydraulic jumps were created across the tank surface. Most of the air bubbles broke in the boil over the plates or in

the jumps, and were not carried across the tank. In the baffled sections the aeration appeared to be much less violent, although the spiral flow was still well pronounced; air bubbles could be seen to be breaking over from one-half to all of the tank surface.

Those of you who visited the plant yesterday probably noticed that while the total air used and the total sewage treated are metered, there is no provision for determining the division of the air or sewage between the two aeration tanks. In order to determine the advantages of the baffles, it was necessary to know the percentages of the total air and sewage flows that were used in each tank. The method of determining these values will be briefly stated before further considering the merits of the baffles.

Before the baffles were installed, the proper setting of the valves at the inlets of the air ducts to obtain equal distribution of air between the two tanks could be determined by the appearance of the tanks. After the baffles were installed, the same valve settings were maintained, so it is reasonable to believe that equal volumes of air were used in each tank.

Although there is no provision for measuring the sewage flow to each tank, the returned sludge is introduced into each tank over a weir so that, by reading the head over these weirs hourly, a fairly accurate determination of the amount of sludge used in each tank could be obtained. Several volumetric and gravimetric tests showed that at all rates of returning sludge the solid contents of the portions going to each tank were the same. If, then, the amount of sludge returned to each tank could be so regulated that the ratio of sludge to sewage in each tank was the same at all times, the division of the total amount of sludge returned between the two tanks would equal the division of the total sewage flow between them. To accomplish this, samples were collected hourly from each tank at a point 8 ft. beyond the entrance of the settled sewage and centrifuged to determine the volume of contained sludge. After a little practice, the operators were able to so regulate the rates of returning sludge that at any given time the volumes of sludge in the two tanks, as determined in this way, were practically identical. As a check on this method, the volumes of sludge in the tanks were determined hourly by sedimentation in glass graduates and the suspended-solid content of the two tanks was determined twice daily, at 9 a. m. and 7 p. m. As may be seen from Table II, it was possible to keep the solid content practically the same by these methods.

By these rather crude measurements an attempt was made to determine the advantage of the baffles, if any. To do this, varying proportions of the total sewage flow were treated in the baffled tank. The mixed liquor from the baffled tank was sent to one final clarifier, and the liquor from the unbaffled tank was sent to the other clarifier. The relative stabilities of the two effluents were determined daily at 4 p. m. The results of these runs are given in Table II. The average difference in suspended solid content of the two tanks is included to give some idea of the accuracy of the method used for determining the division of flow.

TABLE II

Effect of Baffles in Aeration Tanks

Per Cent of Total Flow Through Baffled Tank	Length of Run, Days	Difference in Suspended Solid Content of Two Tanks	Relative Stability of Effluents	
			Baffled	Unbaffled
52.5	6	5.70%	59.0%	48.6%
52.8	10	1.30%	94.0%	94.0%
54.0	9	0.75%	98.6%	90.3%
54.7	12	0.21%	72.5%	88.2%
58.2	20	0.19%	8.4%	28.4%

These tests show that in order to obtain the best results from both tanks the baffled tank should receive 53 to 54% of the total flow, or 13 to 17% more flow than the unbaffled tank. It seems probable that if the baffled tank had baffles throughout its entire length instead of only half that length a still further improvement could be found.

From the aforementioned differences in appearance of the surfaces of the two tanks it was believed that much of the benefit of the baffles was due to a lengthening of the contact period of the air with the liquor. But, inasmuch as the baffles were designed to prevent short circuiting as well, it was decided to make a further test to determine whether or not that was being accomplished. Therefore, all sewage was shut out of both aeration tanks and their contents aerated over night. During this aeration period, the return sludge pumps were kept running, thereby circulating the liquor from final clarifiers to aeration tanks and back again. When the oxygen content of the aeration tanks and clarifiers had become stabilized, sewage was turned into the two tanks and the drop in dissolved oxygen content of the supernatant liquor in the two clarifiers was determined. The volume of sludge in the aeration tanks was determined hourly throughout the run by means of the centrifuge and it was intended to so govern the rate of returning sludge to the two tanks that the amount of sludge in each would be the same, thereby determining the sewage flow to each. This attempt met with rather poor success during the first hours of the run, but it is probable that 15 to 22% more sewage passed through the baffled tank than through the unbaffled one. In spite of this the drop in dissolved oxygen content of the clarifier receiving the liquor from the baffled tank was considerably less rapid (although eventually slightly greater) than that in the clarifier receiving the flow from the unbaffled tank. Table III gives the results of this run. It is apparent that although sewage was entering the baffled tank at a higher rate than it was the unbaffled one, a greater length of time was required for it to pass through, thus showing that the baffles were effective in greatly reducing short circuiting.

Although these experiments were rather crude, they showed so conclusively the benefits of the baffles that it is planned to make the baffles continuous throughout both tanks as soon as possible. However, the flow in the river has been so low this summer that it was considered advisable to wait until the winter to take the tanks out of use long enough to make the change.

Conclusions—Our experiences at Salinas serve as further proof of the opinions of Mohlman and Wheeler, who state that their studies "indicate a decided economy in air requirements when the spiral-flow

TABLE III

Time	Volume of sludge at inlet of tank as determined by centrifuge. Unbaffled	Baffled	Amount of sludge returned during following hour (gal. Unbaffled	Baffled	Dissolved oxygen in clarifier receiving flow from tank. Unbaffled	Baffled
8:00 a.m.	.....	.....	6510	6510	....	....
8:30 a.m.	.....	.....	.....	.....	6.7	6.8
9:00 a.m.	.....	.....	6825	6825	....	....
10:00 a.m.	4.00%	3.84%	7140	7140	....	....
10:30 a.m.	.....	.....	.....	.....	5.5	5.7
11:00 a.m.	4.00%	3.66%	6510	6825	....	....
12:00 m.	4.16%	4.00%	6165	7140	1.6	2.3
1:00 p.m.	4.00%	3.84%	6165	6825	....	....
1:30 p.m.	.....	.....	.....	.....	0.9	1.0
2:00 p.m.	4.16%	4.00%	5820	7140	....	....
3:00 p.m.	4.00%	4.00%	5820	7140	0.7	0.9
4:00 p.m.	4.00%	4.00%	5820	7140	....	....
4:30 p.m.	.....	.....	.....	.....	0.6	0.5
5:00 p.m.	4.67%	4.67%	5820	7140	....	....
6:00 p.m.	4.33%	4.33%	5820	7140	....	....
7:00 p.m.	4.67%	4.67%	5820	7140	....	....
7:30 p.m.	.....	.....	.....	.....	0.4	0.3
8:00 p.m.	4.67%	4.67%	.....	.....	....	....

type of design is correctly interpreted." Its efficiency depends upon the proper placing of the diffuser plates, the proper rate of air through the plates, the tank dimensions, the use of baffles and other variable factors. If these factors are not considered properly, all the benefits of this improvement may not be realized. Hurd, the originator of spiral-flow tanks, states that the entire design of the tanks should be dependent upon the character of the sewage being treated.

We have been fortunate in finding a method of greatly increasing the efficiency of our aerators at very nominal expense, but we still have no assurance that after all the baffles are installed we will have the most efficient aerators possible for the Salinas sewage. In view of the wide number of varying factors that influence aeration efficiency, the most efficient type of aerator could only be determined after a rather extensive series of experiments. In fact, aeration-tank proportions are just one of the many features of the design of the modern sewage treatment plant that should be based on thorough experimentation under the particular conditions to be met if the highest efficiency is to be obtained.

In this day of highly developed and complicated sewage treatment plants, it would be very desirable to base all plant designs on a series of previously conducted experiments with the particular sewage to be treated. Because of the unusual character of the Salinas sewage, the need of experimentation is probably more evident there than it would be at many places. But, it is believed that only after city officials in general have been brought to understand the need of experimentation can the designing engineers create the most efficient type of plants for sewage treatment.

REFERENCES

1. The Concentration of Excess Activated Sludge and Its Digestion with Primary Sludge in Separate Tanks by T. R. Haseltine, Sewage Works Journal, October, 1931.
2. Results of the First Year's Operation of the Salinas, California, Sewage Treatment Plant, by T. R. Haseltine, Western Construction News, September 10, 1931.
3. Activated Sludge Experiments at the Calumet Sewage Treatment Works, by F. W. Mohlman and C. E. Wheeler, Sewage Works Journal, October, 1930.
4. Distinctive Characteristics of the Indianapolis Sewage Treatment Plant, by Charles H. Hurd, Sewage Works Journal, October, 1929.

SOME PRACTICAL IMPROVEMENTS IN OPERATION RESULTING FROM RESEARCH AT GRIFFITH PARK EXPERIMENTAL STATION, LOS ANGELES

By R. F. GOUDEY*

While research at the Griffith Park experimental station has by no means been completed, nevertheless certain improvements in the operation of the activated sludge process have been so firmly established that a discussion of them now appears timely. Some of these features include simplification of the sludge disposal problem, elimination of overflow liquor beds from digesters, more efficient sedimentation, paddle-wheel aeration, and control of sludge bulking.

Sludge Disposal Problem—Activated sludge plants such as Pasadena and Milwaukee convert all sewage solids into a sludge about 99.5% water, having a volume of 15,000 to 50,000 gal. of excess sludge for each m.g. of sewage treated. This sludge is difficult and costly to dewater—it is the extreme at which the maximum volume of sludge is produced and gives an aggravated sludge problem.

The remedy lies in reducing the excess sludge volume to a minimum. This can be accomplished to a great extent by preventing sludge, which can be intercepted as fresh sludge by sedimentation, from reaching the 99.5% water condition. Since fresh sludge runs 90% to 94% water preliminary sedimentation reduces the total sludge very materially, particularly when efficient sedimentation up to 80% removal of solids is employed. In fact, the reduction in total excess sludge volume by this procedure alone is over 50%. At our plant, with 80% removal of solids by sedimentation the excess activated sludge amounts to 15,000 to 20,000 gal. per m.g. of sewage treated.

The next step in reducing excess activated sludge volume, and which can be used when efficient preliminary sedimentation is employed, is the pumping back of the excess activated sludge ahead of the preliminary clarifier at a low and more or less uniform rate. This has been done for over a year at our plant.

The sludge loses its identity, apparently reflocculates and consolidates itself with the fresh sludge, and increases the water content of the fresh sludge little or none. The total volume of fresh and excess activated sludge produced by this method is 6800 gal. per m.g. of sewage treated. This volume is just one-tenth what it would be if preliminary sedimentation were not employed. Certainly this is a big step forward in improved operation. Experiments in thickening this material before or/and particularly after digestion will still further reduce its volume.

Drying of digested sludge on sand beds, even in California, where drying conditions are at times favorable, is a costly and unsightly procedure. In a large plant, the cost of land for beds is a big item in itself. Our experiments have conclusively proven that the digested sludge

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can be conditioned with ferric chloride with or without celite or heat, can be dewatered by vacuum equipment to 65% to 80% water, and can be dried to 10% moisture at less cost than sand-bed installation and operation. The final product at 3% nitrogen can be sold at current low prices for a dollar more per m.g. than it costs to produce it, without any allowance for gas recovery and utilization.

Thermophylic digestion was given a 2 months' trial and was a dismal failure. Gas production was cut to 50% normal, the sludge had a disagreeable sweetish odor, it was most difficult to dewater, the cracks on drying appeared only at the surface, the underneath sludge resisted dewatering, flies were attracted, nitrogen content was lower, and over 3 months were required to get the digester back to normal.

Overflow Liquor—Just why all digesters are operated by allowing so-called supernatant liquor to overflow when sludge is pumped in is not clear, as it results in a sufficiently large volume of sludge solids to be washed out of the digester to cause a nuisance. Theoretically, the water-content of digested sludge should be higher than fresh sludge because of the 45% reduction of volatile solids—in practice it actually has more. The increase in solids is not proportional to solids added to the digester, because of what escapes in the overflow. The overflow beds are a nuisance, and where the overflow liquor is put back into the plant its oxygen demand becomes a load on the plant.

We operate by allowing digested sludge to be removed from the bottom of the digester into a storage tank simultaneously with the pumping in of fresh sludge. When the storage tank is filled it is emptied onto sand beds, and there is no overflow liquor at all. The digested sludge has a higher water content, but is readily amenable to thickening or dewatering. By this method, the digester is kept full at all times and the gas collection system is not put out of commission by the withdrawal of sludge, as is the case when sludge is drawn from other digesters.

More Efficient Sedimentation—Most clarifiers used for preliminary sedimentation are still designed on the detention basis instead of surface area. One need only put sludge into a liter graduate and some more into a 2-qt. jar to see how more efficient the latter is from the standpoint of time. Preliminary clarifiers designed from 1500 to 2500 gal. per sq. ft. per day give roughly 30% to 40% removal of suspended solids. One plant now has clarifiers based on 935 gal. per sq. ft. per day and obtains 55% to 60% removal. At our plant the rate is 615 gal. per sq. ft. per day and the removal is 80%. It appears that even better rates would be justified.

Settling of activated sludge has been given a great deal of thought and it is an entirely different problem than settling sewage. Raw sewage is adapted to cross-flow sedimentation, and deposited sludge can only travel by mechanical means to an outlet. Activated sludge is different. When sludge reaches the bottom of the tank it produces a blanket and flows to maintain a uniform thickness of the blanket over the entire bottom of the clarifier. There is a complete separation of sludge and water. Clear water through upward flow is at the surface in all parts of the tank, even over the inlet.

In a square clarifier with a cross-flow, and particularly in long narrow tanks, the current is sufficient to pick up small particles of floc and defeat good sedimentation. The solution is not so much more weirs built out into the tank (for they do help immensely), but to install an auxiliary revolving outlet weir at the top, which skims off water over all parts of the tank. The weir is not in one place sufficiently long to set up a current and, with additional side weirs, adequate length can be easily obtained to insure good sedimentation.

When operated on such a basis the clarifier virtually becomes an upward-flow tank, which principle has been observed in England and Germany as the best method for settling activated sludge.

Clarifiers with 500 gal. per sq. ft. per day settling rate are justified when it is desired to really clarify activated-sludge effluent.

Double sedimentation likewise is justified, as it gives a factor of safety during sludge-pump intermissions for any cause whatsoever.

Paddle-Wheel Aeration—Most types of aeration require 30 h.p. per m.g. to operate; some take even 65 h.p. per m.g. Paddle aeration plus power to deliver 0.5 cu. ft. of air per gal. for a very strong industrial sewage at our plant totals 15 h.p. per m.g. The aeration is calm, efficient and economical. Its superiority over other types of aeration is obvious.

Addition of air and mechanical agitation therefrom is an inefficient procedure when air is supplied by compressors. Our present experiments eliminate the compressor method of introducing air with consequent motor, compressor, pipe and filtros plate losses, by introducing it in buckets placed on the ends of the paddles and which release air in the lower part of the tank. Although the bubbles are not as fine as with filtros plates, sufficient air is added to maintain a suitable environment for the activated sludge process. The cost appears to be less than 10 h.p. per m.g.

When one realizes that oxygen from the air cannot be used direct, but only through the intermediary of enzyme activity which makes organic matter receptive on one hand and oxygen on the other hand available, it becomes evident that aeration is chiefly an environmental factor.

Control of Sludge Bulking—Sludge bulking, either deliberate or intentional, cannot occur when sludge is properly conditioned and reaerated. This may sound dogmatic. Up to last January, sludge bulking at our plant was a regular occurrence. It could be corrected by lime when due to mash or fruit-sugar wastes, or by dilution when due to pectins. Outside ingredients apparently slowly affected the sludge, which easily would swing one way or the other. Why should not such sludge, when not properly harnessed, be as fickle as the winds?

A discussion of the microscopical, bacterial and chemical analyses of activated sludge collected daily before and after conditioning is too long a story to tell here, but from the practical standpoint some idea of how sludge can be made to behave is timely. The sludge is conditioned with chlorine, food, and dilution water during reaeration.

Returned sludge before reaeration is first chlorinated with the final effluent for two reasons: first, for partial disinfection, and, second, for dilution. The chlorination process kills off the weaker organisms and releases enzymes. A new and vigorous growth supplants them. Sterilization of sludge has been carried to below 500,000 per c.c. Food is next added in the form of settled sewage, which we believe is an important factor in building up good sludge. Dilution of the sludge with final effluent is important also. Whether the good effect is due to enzymes or bacteriophage which are known to be present, or to relieving concentration of end products, we are not sure. The fact remains that the sludge recoagulates, builds itself up into a large floc, and gives a distinct separation between sludge and water.

This type of conditioned sludge has controlled bulking of sludge 100% since last January, and when used in bottle experiments could not be deliberately bulked. The plant also is able to stand severe jolts with daily B.O.D. values rising to over 1000 p.p.m. without harm.

In addition to controlling bulking, this process will justify design of an aeration period of 3 hr. with 35% returned sludge by volume.

General—The fact that some of these features are of practical value is borne out by a comparison of chemical results from average results at eastern plants.

Method of Treatment	Suspended Solids P.P.M.	Oxygen Demand 5 Days P.P.M.
Aver. 7 eastern sprinkling filters	35	38
Aver. 6 eastern activated sludge plants	23	18
Aver. Griffith Park experimental station	11	4.6

OPERATION OF TYPICAL SEWAGE DISPOSAL PLANTS IN CALIFORNIA AND COMPARISON WITH RESULTS OBTAINED ELSEWHERE

By E. A. REINKE*

As a result of insistent desire for research to be done by the State Department of Public Health on sewage and waste disposal problems, a survey of existing plants was conducted during 1930-31. A few typical plants were selected and detailed field and laboratory tests were made at each. Tests were made with little or no advance notice, so results may be considered typical.

Plants Studied—Plants at St. Mary's College, Santa Barbara General Hospital and San Diego State Teachers' College were tested once for periods of 2 to 3 days. Those at Salinas, Lodi, Ojai, Pasadena, San Bernardino, Escondido and Pomona were tested twice for periods of 3 to 5 days.

It is interesting to note that in comparison with similar studies made by the United States Public Health Service in 1920 of 15 representative plants in the United States, our California communities produce sewage 2 to 3 times as strong and the plants remove 2 to 4 times as much putrescible material, showing better efficiency in removal of suspended solids and oxygen-demanding materials than do the eastern plants.

The average removals effected by settling tanks were 65% of suspended matter, 44% of B.O.D., and 19% of total nitrogen.

The oxidizing devices, including final settling, showed average removals of 58% of suspended matter, 88% of B.O.D., and 70% of total nitrogen.

Overall removals averaged 85% of suspended matter, 93% of B.O.D., and 76% of total nitrogen.

A comparison of oxidizing devices showed that sand filters removed 88% of suspended matter, 95% of B.O.D., and 84% of total nitrogen. Activated sludge plants removed 88% of suspended matter, 96% of B.O.D., and 75% of total nitrogen. Sprinkling filters removed 76% of suspended matter, 86% of B.O.D., and 66% of total nitrogen.

All the above data are given in Tables I and II, p. 48.

The studies brought out in addition—a fact previously mentioned by others—that even with faulty design, negligent operation, overloading, presence of abnormal wastes, and other unexpected contingencies, sewage disposal plants cause a marked improvement in the appearance and change in constituents of the sewage received.

It is a relatively simple matter to remove 30 to 50% of the B.O.D. and suspended solids of a sewage by settling, but to consistently remove more than 50% requires a combination of good design and careful operation. Similarly, sprinkling filters will easily remove 60 to 75% of the B.O.D. of the applied sewage, and activated sludge plants

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90 to 95%, but to get consistent residual B.O.D. in the effluent below 20 p.p.m. calls for an understanding by the operator of the intricacies of plant management, and watchful care at each step.

We must not lose sight of the fact that financial considerations frequently limit the efficiency of the plant, but each operator should make it his duty to get the most out of his plant for the time and money available.

To continue on the results of studies made, they may be briefly summarized by plants as follows:

Lodi, with the first municipal activated sludge plant in the state, treating during test periods a normal domestic sewage, showed a removal of 92% of B.O.D., leaving 10.7 p.p.m.; 85% of suspended matter, leaving 16 p.p.m., and 41% of total nitrogen, leaving 17 p.p.m. Oxides of nitrogen totaled 1.3 p.p.m.

Salinas, one of the latest activated sludge plants in the state, treating a very strong sewage of unusual character, removed 94% B.O.D., leaving 31 p.p.m.; 93% suspended matter, leaving 21 p.p.m., and 45% of total nitrogen, leaving 27.5 p.p.m. Oxide of nitrogen totaled 1.4 p.p.m. With one-half flow, this plant removed 98, 94 and 83%, with residuals of 8.3, 25 and 8.0 p.p.m., and the effluent contained 17.8 p.p.m. oxide of nitrogen.

Pasadena, one of the early activated sludge plants in the state, treating a strong domestic sewage, showed a removal of 96% of B.O.D., leaving 14.3 p.p.m.; 88% of suspended matter, leaving 42 p.p.m., and 73% of total nitrogen, leaving 13 p.p.m. Oxides of nitrogen totaled 5.5 p.p.m.

Pomona, having an activated sludge plant preceded by an overloaded Imhoff tank, showed removals of 98% B.O.D., leaving 4.9 p.p.m.; 83% suspended matter, leaving 44 p.p.m., and 94% of total nitrogen, leaving 2.6 p.p.m. Oxides of nitrogen totaled 7.5 p.p.m.

Escondido, another later activated sludge plant, treating average domestic sewage, removed 97% B.O.D., leaving 6.8 p.p.m.; 88% suspended matter, leaving 32 p.p.m., and 87% total nitrogen, leaving 5.0 p.p.m. Oxides of nitrogen totaled 4.5 p.p.m.

Santa Barbara County General Hospital, an institutional plant of the activated sludge type, employing a Watsco aerator, showed removal of 99% of B.O.D., leaving 4.5 p.p.m.; 73% suspended matter, leaving 50 p.p.m., and 84% total nitrogen, leaving 4.0 p.p.m. Oxides of nitrogen totaled 4.8 p.p.m.

San Bernardino, the largest Imhoff tank-sprinkling filter installation in the state, showed 91% removal of B.O.D., leaving 26 p.p.m.; 85% of suspended matter, leaving 36 p.p.m., and 81% of total nitrogen, leaving 7 p.p.m. Oxides of nitrogen totaled 6.3 p.p.m.

Ojai has a small plant with settling, sprinkling filters, and sand filters. The sprinkling-filter effluent, which included sludge liquor run directly to the filters, showed removals of 92% B. O.D., leaving 47 p.p.m.; 90% suspended matter, leaving 75 p.p.m., and 59% total nitrogen, leaving 14.5 p.p.m. Oxides of nitrogen totaled 8.2 p.p.m. Including the sand filter, the B.O.D. reduction was 99%, leaving 5.4 p.p.m.; suspended matter 97%, leaving 22 p.p.m., and total nitrogen 96%, leaving 3.2 p.p.m. Oxides of nitrogen were 11.8 p.p.m.

St. Mary's College has an institutional plant with Imhoff tank, sprinkling filter and sand filters. The dosing siphon was not functioning, sewage trickling through the sprinkling filter continuously during part of the test. In spite of this condition, the removals shown were 70% B.O.D., leaving 73 p.p.m.; 77% suspended matter, leaving 66 p.p.m., and 32% total nitrogen, leaving 30 p.p.m. Oxides of nitrogen were 4.9 p.p.m. The sand-filter effluent showed total removals of 90% B.O.D., leaving 24 p.p.m.; 92% suspended matter, leaving 22 p.p.m., and 93% total nitrogen, leaving 3 p.p.m. Oxides of nitrogen were 12.1 p.p.m.

San Diego State Teachers' College has a new institutional plant with settling, sprinkling filters and sand beds. After a few days' operation, overall removal was 96% B.O.D., 65% suspended solids, and 53% total nitrogen. Residuals were 7.6 p.p.m. B.O.D., 56 p.p.m. suspended matter, 23 p.p.m. total nitrogen, and oxides of nitrogen 3.1 p.p.m.

In addition to the measurable tests at each plant, notes were made of other items, particularly general cleanliness, weed control, beautification, and interest of operator.

As might be expected, it was found that the plants producing the best results also rated high in the items noted. Another significant feature was the improvement noted between the first and second visits.

Sewage plant managers, superintendents and operators are in general interested in their work and anxious to get the best results possible. Good operation is easy to talk or write about, but often difficult to accomplish. What appear to be little things frequently make or break a plant from the operator's viewpoint. For example, let us consider some of the more common units of a sewage disposal plant:

Bar Screens, if of proper size and construction and well located, perform an extremely useful function at most plants, by protecting pumps and relieving succeeding units of rags, sticks and unsightly larger solids. If the task of cleaning and removing solids is clean, simple and convenient, much time and labor is saved and incentive is created. Self-cleaning mechanical screens are ideal, but where the cost does not seem justified, hand-cleaning at least twice a day is required. The screen should be located to give roominess and good air circulation, so that working around it will not be an odious task. It should be constructed large enough to allow partial clogging between cleanings without unnecessary backing up of sewage in the outfall. Frequent difficulties observed are too large openings, allowing all except large sticks to pass; too small openings, requiring frequent cleaning or overflow where no provision is made; combination with grit chambers with poor provision for removal of grit, or such large capacity that they act as septic tanks; and no provision for draining and removal of material screened. A platform with perforations or bars, such as recently built by F. J. Rossi at Modesto, takes overflow as well as serving to drain screenings. Basket screens with windlass for lifting, as at Escondido, Alturas and Sebastopol, are good in deep sumps.

Too often an otherwise presentable plant has in one corner, over a bank, or in an open pit, an unsightly, fly-breeding odorous collection of screenings from the bar screens. Collection in tightly covered cans and disposal by burial or burning is generally the approved plan for

small plants, or they may be dried on screen grid and burned, as at Patton. Here a rag picker, resembling meat hooks, across the inlet to an Imhoff tank, takes out most simply a surprising lot of rags, ropes and papers.

Imhoff tanks still lead in number as settling devices in this state. Few are provided with convenient means for dealing with scum in flow-through compartment or in the gas-vent areas. The method employed is to push down or hose down the scum, only to have much of it bob up again, as well as foul the effluent. San Bernardino and Los Gatos have scum overflows. Walks are usually located for structural economy rather than convenience to operator. Tanks built above ground with no railings are dangerous, and liabilities to the city. Davis Farm is a good example of protection. In many cases no water supply is available for cleaning or to allow the operator to wash after working around the tank. Screen houses over tank as at Patton, Norwalk Hospital and Montezuma School for Boys are light, airy, and keep scum soft. To my mind, these screened houses are superior to tighter housing. Where sludge capacity is limited or inadequate, sludge beds are often too small, and the tank does not accomplish the purpose for which it was designed.

Clarifiers for raw sewage, with mechanical removal and separate digestion of sludge, are coming into favor in California as well as in other parts of the country, and seem to confirm the contention that foaming and scum troubles are greatly reduced, if not eliminated. Arrangement of inlet devices, scum removal and sludge removal facilities are often faulty, and the problem of handling overflow liquor is frequently troublesome. At Salinas, scum difficulty is minimized by a flotation tank for skimmings, with liquid returned to raw sewage. At the March, 1931, meeting of the New Jersey Sewage Works Association, Leroy Forman presented a paper giving results of studies at various separate sludge digestion plants, from which the following concerning settling tanks with or without mechanical scrapers is quoted:

"In the operation of plain settling tanks, too long a detention period is detrimental. * * * Solids should be removed either continuously at a low pumping rate or twice daily at a greater pumping rate. It is essential to keep the tank as free as possible from accumulated solids, because fresh solids digest more quickly, and because of their nature are very putrecible and easily ferment, producing excessive foaming, scum odors, etc."

The use of a timed switch for sludge removal, as at Santa Barbara County General Hospital, seems desirable.

Separate sludge digestion with gas burning is now practiced at Chico, Salinas, Los Angeles County Sanitation District, San Bernardino, Escondido, Pomona and other plants and is helpful in odor control, cleanliness and operating efficiency.

Siphons in general receive little care. Regular cleaning and flushing, and checking up for air leaks to prevent continuous discharge, are important operating procedures. Stoppage by grease and air leaks are most common difficulties.

Sprinkling filters require cleaning of nozzles, flushing or draining distribution line, and resting or treating to prevent pooling. A galvanized iron screen, of about No. 6 mesh wire, ahead of the dosing siphon

will catch most of the larger particles such as matches, gum, and balls of grease, and thus save operating attention. Convenient means for flushing or draining, and valves for cutting out part of the bed for resting, are also desirable. Removal of nozzle spindles for one discharge is a convenient method of cleaning, but allowing them to remain off any longer only cuts down filter efficiency. Variation of clearness of effluent is due to unloading of slime from rock surfaces, and is to be expected in all filters.

Secondary settling tanks following filters should be provided with ample sludge capacity to take care of unloading periods, otherwise the final effluent at such times will be little better than that of the filter itself; furthermore, the discharge is usually cyclic, and the tank should be large enough to equalize the flow. Separate sludge digestion is satisfactory or return of sludge to the inlet of the primary settling tank, provided the rate of return is not too high. Plain settling tanks, Dortmund tanks, Imhoff tanks, and mechanically-operated clarifiers are all used in this state, and if of proper size and kept free of excess sludge, all are satisfactory.

Activated sludge plants probably present the most varied design and operation of any treatment methods. Ideas, experiments and experiences at different plants are so varied that the designer would do well to allow ample size and the greatest possible flexibility in operation. Among the more common points frequently overlooked are: provision for carrying sludge return, use of a sufficient number of units to allow changes in number used for aeration and for reaeration; equalization of peak flows; arrangements for addition of sewage or return sludge at a number of points; continuous wasting of excess sludge; provision for cutting out one or more units for alteration, repairs, or experimental use.

English practice tends toward mechanical aeration, while in this country the majority of plants built have used air under pressure. Recently a combination has come into favor, as now being experimented with by R. F. Goudey at Los Angeles. Mechanical aeration does not produce as complete treatment or as polished an effluent as is obtained by use of air blowing, and this fact probably accounts for the reluctance of most American engineers to use it. An interesting point observed in reading literature on activated sludge is the conservative attitude adopted by engineers in plant design, which, however, is conservative as to cost of construction rather than in provision of flexibility and capacity for unusual sewage or sewage flow. For example, A. J. Martin's Activated Sludge Process reports that experiments with reaeration of sludge have indicated for some sewages a marked advantage in using long periods and diluting sludge with sewage, but many plants in this country provide no reaeration or only partial reaeration, consisting of blowing air through the sludge on its return from final clarifiers to the aeration tanks. Plants are all too frequently overloaded and, if of sufficient size, operation is usually made as economical, or perhaps better, as cheap as possible, with little or no attempt to modify operation for varying character and quantity of sewage flow.

Sand filters, as used at St. Mary's College, Ojai, and San Diego State Teachers' College, serve a useful purpose in continuously produc-

ing a sparkling-clear stable effluent with a minimum of technical supervision. They are adapted to small plants where the relatively high construction cost as compared with activated sludge is balanced by the lower attendance and operating costs and security afforded by a continuously good effluent. If operated flooded as slow sand filters, they give remarkable bacterial efficiency, but may cause algal growths and odors necessitating their intermittent operation.

Sewage ponds, or lagoons, as they are termed in Germany, are used at Merced, Santa Rosa, Sonoma, Modesto, Calistoga and Sebastopol. They have furnished a cheap and effective method of overcoming odor nuisances where land is available and isolation reasonably good. They depend on algal growths for successful operation, the oxygen produced by the algae preventing septicization. Wind and sunlight, distribution and dilution with pond water are important factors. Care must be taken to control mosquitoes. Area factors vary from 2 to 20 acres per 1000 people.

The Sacramento river at Sacramento this summer was in reality a 500-ac. sewage pond, with little or no upland flow and distribution effected by wind and tide. Algal growths kept the water from becoming septic, dissolved oxygen tests showing from 25 to 200% saturation. Population equivalent in terms of B.O.D. was somewhat over 200,000, giving an area factor of 2.5 ac. per 1000 people.

Chlorination is an old story to many of you. It was surprising to find how many chlorinators were out of use for varying periods due to lack of repair parts, no chlorine on hand, and various minor difficulties, all of which resulted in no sterilization. Of seven plants with chlorination visited during periods of tests, six had interruptions. It seemed obvious that where sterilization was needed there should have been duplication of chlorinators, scales, chlorine cylinders and chlorine rooms, and enough repair parts on hand to make simple repairs at the plant.

Conclusion—Generally, regardless of the methods of sewage treatment, we find the viewpoint of the city in the past has been somewhat as follows: A sewage disposal problem presented itself and, on the advice of the State Department of Public Health, an engineer was hired to make a report. After investigation a plant was designed, money voted, and the project constructed. The cost of operation mentioned in the engineer's report seemed reasonable, but when bills actually are paid they seem excessive. The town has not grown as fast as estimates indicated, and revenues are low. Demands for street work, lighting, parks, etc., came in, and the sewage work was left to the city engineer, superintendent of streets, or plant operator, with instructions to keep down costs. If no complaints of odor or nuisance came before the town board, the plant was allowed to drift, and requests of the operator for materials, supplies or repairs were put off as long as possible.

Gradually, municipalities are awakening to the fact that sewage disposal is an important civic responsibility. In a few places, sewage effluent is sold for irrigation, in several sludge is sold for fertilizer; in many, sewer farms are improved to a point where they become the show place of the neighborhood rather than the shunned sewer dump. As water shortage continues and becomes more acute, the value of

sewage for irrigation becomes more appreciated as a certain continuous supply, and with appropriate treatment, depending on its proposed use, we can look forward to its more extensive utilization in California.

The success of sewage disposal after all depends on cooperation of municipal officials and the operating staff. If the operation is reliable, the plant clean and presentable, and the effluent uniformly good for the type of plant used, the officials will, as they should, take pride in bringing citizens and visitors to see how the sewage is handled.

The California Sewage Works Association is continuing its work of creating a new vision of sewage disposal and, by an interchange of ideas of those interested, bringing about better operation of sewage disposal plants in our state.

TABLE I

	Settling Tanks	Oxidizing Devices	Overall	Sprinkling Filters	Sand Filters	Activated Sludge
Percent Removal						
B. O. D.	44	88	93	86	95	96
Suspended matter	65	58	85	76	88	88
Total nitrogen	19	70	76	66	84	75

TABLE II

	Lodi	Salinas (all)	Salinas (½ flow)	Pasadena	Pomona	Escondido	Santa Barbara Hosp.	San Bernardino	Ojai	St. Marys Coll.	San Diego Coll.
B. O. D.											
Raw	139	496	537	375	262	245	367	298	614	239	170
Final	10.7	31	8.3	14.3	4.9	6.8	4.5	26	5.4	24	7.6
% Removed	92	94	98	96	98	97	99	91	99	90	96
Suspended Matter											
Raw	107	295	431	350	262	256	188	249	803	290	158
Final	16	21	25	42	44	32	50	36	22	22	56
% Removed	85	93	94	88	83	88	73	85	97	92	65
Total Nitrogen											
Raw	29	50	48	48	45	37	25.5	37	76	44	49
Final	17	27.5	8	13	2.6	5	4	7	3.2	3	23
% Removed	41	45	83	73	94	87	84	81	96	93	53
Oxides of Nitrogen											
in efflu	1.3	1.4	17.8	5.5	7.5	4.5	4.8	6.3	11.8	12.1	3.1

THE STATE DEPARTMENT OF PUBLIC HEALTH AND ITS RELATION TO THE SEWAGE WORKS OPERATOR

By GILES S. PORTER,* M. D.

The constitution of the state of California specifies that "The legislature shall provide by law for the maintenance and efficiency of a state board of health". The legislature has established the California State Department of Public Health to carry out provisions of the various health laws.

Among the many state health laws, one of the most important is the Public Health Act which contains provisions requiring permits to construct and operate sewage disposal works, and allows revoking of such permits in the event a nuisance or menace to health is created.

The permit actions are taken by the State Board of Public Health after a report and recommendation have been made by the Bureau of Sanitary Engineering. For many years permit actions were a major part of the bureau activities, through the fact that projects to abate long-standing conditions were under way. Now more and more importance is being placed on plant operation to keep these plants tenable, because of complaints of odor nuisance and sometimes because of possible health menace.

The job of operating a city sewage disposal works is usually given to an already overworked official, and he in turn passes it off to an assistant or operator with the idea that the less he himself hears of it the better. When an engineer from the bureau visits the plant he is referred to the assistant, who may or may not be properly qualified to operate the plant. However, he is willing to learn and glad to receive suggestions. If visits can be made at frequent intervals the operator becomes more interested and tries to get the best possible out of the plant, but if not he loses interest and gets by with the least work.

With the limited state funds and bureau staff, frequent visits to sewage disposal plants are not possible, and the gap between the state and the operator is gradually widening. The difficulty may be overcome in several ways.

1. The local officials, mayor, city manager, chairman of sewer committee, or city engineer, should make frequent visits to the works, if only to show an interest in the problems and accomplishments of the operator.

2. Still further, that official should train himself in the fine points of the plant and its operation, and so be in position to give the operator advice of real value.

3. Technical supervision by trained plant operators may be obtained, using full-time men for larger plants and part-time men for smaller plants.

*Director, California State Department of Public Health, Sacramento.

4. Personnel of the Bureau of Sanitary Engineering should be increased by prevailing on the State Legislature to provide additional funds.

The first two methods require primarily an interest on the part of the city officials and would undoubtedly bring about improved plant operation. Technical supervision is being used more and more in the eastern and middle western states. This gives the city a trained man who can devote sufficient time to study plant operation and bring about better results and better cooperation of all parties concerned. Increase of bureau personnel is feasible, but tends toward centralization of government and may be opposed by the group of citizens who feel that we have now too much state control and too much taxation.

It is plain, I think, that ground will be gained in the more satisfactory and creditable standing of our sewage works if any or all of the several plans outlined can be developed with the definite purpose of bringing stimulus and correct technical procedures to the routine operator. The result is bound to be better support by the public. Therefore, try and bring your city officials to your plant. Let them see where and why you need money for a particular purpose and you are on the road to the solution of your major problem. We shall do our best to help you stimulate interest in your works and your needs.

Aside from gaining better popular support for sewage disposal is the need of higher training of those who operate the plants. The literature and your meetings are supplying a better understanding of processes and plant function. Many operators, however, see the need of training in control tests, and there has been frequent suggestion that the State Department of Public Health conduct brief schools, for a week or two at a time, for this purpose. The idea is good. We might even be able to conduct the courses at strategic points in the state for the greater convenience of those who would attend them. I feel we are ready to go ahead with this new line of work if the demand warrants.

The California Sewage Works Association is doing a great work and is a live organization. It is the most promising influence on the horizon for stepping up design and operation of this essential civic utility.

YOSEMITE VALLEY ACTIVATED SLUDGE PLANT

By H. B. HOMMON*

Yosemite National Park, California, was established in 1890 and has an area of 1162 sq. mi. Yosemite valley, which is the most interesting section of the park, is 7 mi. long, 1 mi. wide, and has vertical side walls more than 3000 ft. high. On the floor of the valley are the Merced river and two main highways paralleling it, while at the upper end of the valley are the hotel, lodges, public camp grounds, stores, public garages, administration buildings of the government and operators, and residences of permanent employees.

The park was established, and has been developed, for the purpose of preserving for the people of the United States the wonderful scenery within the boundaries, and its population consists of tourists, employees of the government and operators.

Prior to 1927, travel to the park was either by train from Merced to El Portal throughout the year, or by automobile over the Wawona or Big Oak Flat highways, except during the winter months, when these highways are closed to traffic. In 1927, the All-Year highway from Merced to El Portal was completed, and since that time visitors have traveled by automobile to the Yosemite valley throughout the year. The total number of people entering the park in different years is shown by Table I:

TABLE I

Year	People Entering Park
1915	31,548
1920	68,906
1926	274,200
1927	490,400
1931	461,855

Nearly all of these people spend most of their time in Yosemite valley.

The total population on the floor of Yosemite valley at any one time depends on the season of the year. During the winter the permanent population is 750 and, except for the week following Christmas, comparatively few people visit the valley, but during June, July and August the daily population will vary from an average of 5000 to a maximum of 18,570, reached on July 5, 1931. The record census included 6962 tourists in camps, 4085 in hotels and lodges, and 2180 employees, besides daily visitors.

Old Sewage Treatment Plant

Prior to 1921, part of the sewage produced in Yosemite valley was treated in septic tanks and the effluent from the tanks and the untreated sewage were discharged into Merced river. The river was badly contaminated, and in 1921 the firm of Galloway & Marquardt was

*Sanitary Engineer, U. S. Health Service, San Francisco, in charge of sanitation in National Parks.

employed to prepare plans and specifications for a comprehensive sewage system and sewage treatment plant. Galloway & Marquardt retained Charles Gilman Hyde as a consultant on plans for the treatment plant. The consulting engineers submitted plans and specifications for a main trunk sewer line and laterals, and four pumping stations to handle a maximum daily flow of 864,000 gal., and a treatment plant having a maximum capacity of 750,000 g.p.d.

The plans for the sewage treatment plant included:

(1) Imhoff tanks with a detention period of 2 hr., and a velocity of 0.6 ft. per min. through settling basins during periods of maximum flow, and sludge storage for 1 year.

(2) Hyde recommended 15 ac. of natural sand filters, but, due to an inadequate appropriation, only 10 ac. of natural sand beds was uncovered, and the effective filter area was reduced by banks and driveways to 6.3 ac.

(3) Sludge-drying beds with an area of 3500 sq. ft. were recommended, but only half this area was made available.

Measurements of the flow of sewage were made from September, 1929, to September, 1931. The largest volume was produced in June, 1930, when the flow was in excess of 800,000 g.p.d. during 12 days, the maximum flow 854,000, and the average for the month, 784,000 g.p.d. The minimum flow was in December, 1929, when the average for the month was 195,000 g.p.d.

In October, 1930, leakage through the inverts of manholes was stopped and the flow of sewage at the treatment plant was reduced 40%. The maximum flow in June, 1931, was 555,000 g.p.d., and the average for the month was 480,000 as compared with 784,000 g.p.d. in 1930.

The sewage treatment plant was constructed in 1921 and was in continuous operation until August, 1931, when sewage was turned into the new plant. The natural sand filters extended along the Merced river, in some places not over 50 ft. from the banks, and during the 10 years they were in operation no sewage was by-passed to the river. Bacteriological analyses of samples of water collected over a period of 5 years, from the river above and below the sand filters, during the summer, did not indicate any contamination traceable to the sewage filtering through the sand and flowing underground to the river. During the month of June, 1930, the sand filters were operated at rates as high as 127,000 gal. per ac. per day for several days at a time, and at a rate of 105,000 gal. for 3 months. The general plan of operating the filters was to flood one or more of the beds to a depth of 4 or 5 in., allow the surface to dry, harrow the surface, and then rest the beds for at least two days. In the later years, all the beds were ploughed in the spring and all vegetation was promptly removed. About 6 in. of the top sand was removed at one time during the 10 years the filters were in operation.

The Imhoff tanks, consisting of two units, were operated in series and, while there was almost continuous foaming during the summer in the tank receiving the raw sewage, there was but little difficulty from this trouble in the second tank, and the effluent contained only the normal amount of suspended matter. The sewage, however, was

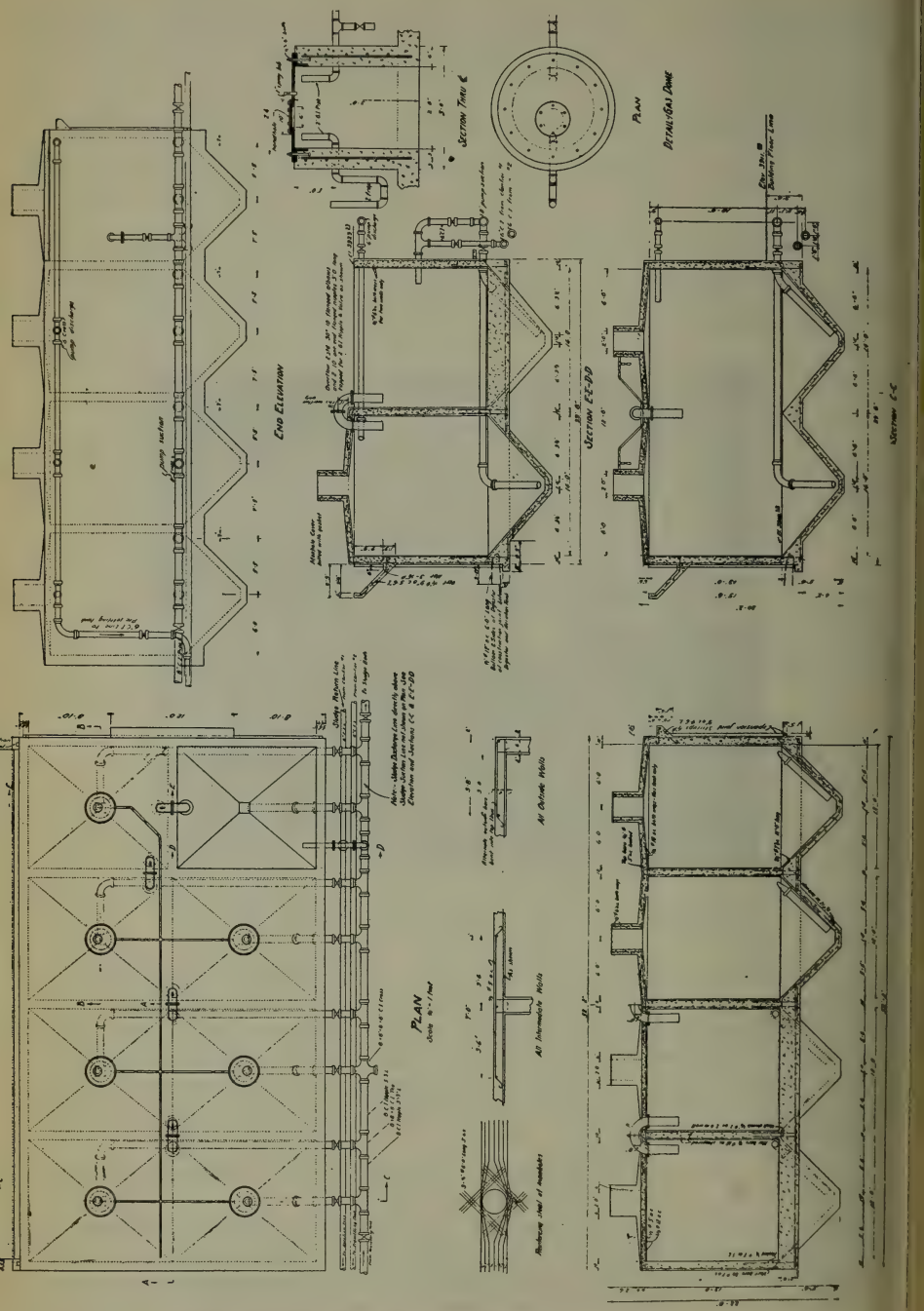
treated with chlorine as it entered the second tank, and this no doubt had some influence in preventing excessive foaming. Sludge digestion, as indicated by gas formation, proceeded at a normal rate during the summer, but in the fall, winter and spring the gasification was very low. Sludge was withdrawn late in the fall each year, but it was never well digested, due probably to the deposit in summer of a large volume of sludge, low temperatures the remainder of the year, and the unfavorable reaction resulting from the unbalanced seasonal deposit of solids.

In the summer of 1925, odors began to appear along the highway near the treatment plant, particularly during the early evening and night, and during the next three years the odors developed into a serious nuisance. An attempt was made to remove or reduce these

(Upper) Sludge-Drying Beds at Yosemite Plant Have Glass-Over. (Lower) Front View of Laboratory, Screened by Trees

odors by constructing a tight building over the Imhoff tanks, adding chlorine at different places to the sewage in the tanks, and operating the sand filters as far as possible to prevent pooling over the sand. All attempts to prevent odors, however, failed. It was believed that the odors came, largely, from the accumulation of organic matter stored in the upper layers of the overloaded sand filters and, to a less extent, from the Imhoff tanks.

In 1927, the number of tourists to the valley had increased to 490,000, and it was necessary to open new areas for camps and other purposes, and to plan for the future. The only land available for extensive developments in the future is along the river opposite and above the old treatment plant, and to enlarge the plant to the capacity required for the future would necessitate clearing 10 ac. or more of a fine growth



Sludge Digestion Tanks at New Yosemite Activated Sludge Plant

of large timber that officials of the park wanted to preserve. In view of these unfavorable conditions, it seemed desirable to abandon the original treatment plant and construct a new one at a more favorable location.

New Sewage Treatment Plant

On account of the odors produced at the old treatment plant and the general objections to having the plant in view of the highways, and since the Merced river is used extensively for fishing and to a limited extent as a source of drinking water, five requirements had to be considered in design and location of the new treatment plant.

1. The plant had to be located where it would not interfere with future developments, and be of a type that would not produce noise that could be heard more than 100 ft. away.

2. A member of the board of expert advisers on general planning of Yosemite National Park stated "No stone should be left unturned in the effort to find a method of sewage disposal which will wholly avoid perceptible odors of sewage along any of the routes of public travel in the valley of the Merced, within or without the park."

3. The landscape engineers of the National Park Service required that the plant be so designed and located that it could not be seen from the two highways that paralleled Merced river on the floor of the valley or from the two highways that pass out of the valley along the north and south walls.

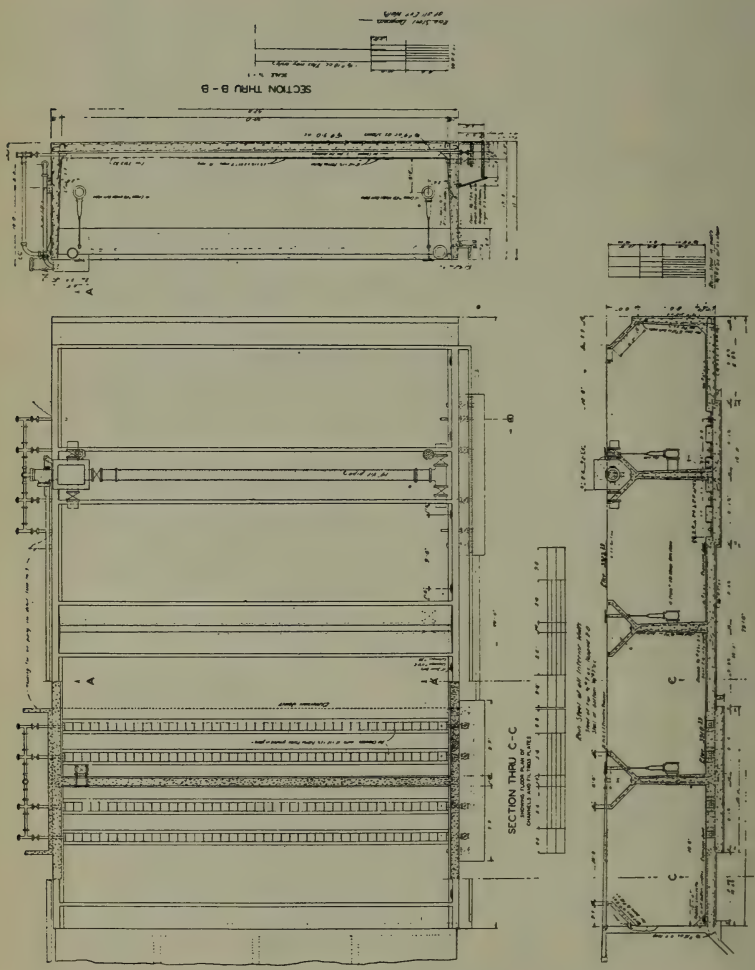
4. The extensive use of Merced river by fishermen who drink water from the stream, and the use of the river water for drinking and domestic purposes by campers and people living along the river outside of the park, required that the stream be kept as free as possible of contamination, and the State Bureau of Fisheries, which operates a fish hatchery in the park and stocks the river with fish, insisted that a treatment plant be designed to produce an effluent that would not kill or interfere in any way with fish in the stream.

5. The treatment plant had to be designed to operate with a maximum flow during the summer four times that of the winter.

Location—As already noted, the Yosemite valley averages in width only 1 mi., and below the old treatment plant the only available land for the new plant consisted of a few small areas lying adjacent to the Merced river and the two main highways. After a careful survey of all the areas that could be used, it was decided that the small strip of ground on the south side of the valley between the river and the highway and ¼ mi. from the foot of Bridal Veil Falls, which is visited by thousands of persons each year, was best suited in every way except for its location so near the falls. At this place, a gravity flow of sewage through the treatment plant could be obtained.

In view of the conditions and the limited number and size of the areas where a treatment plant could be constructed, and proximity of highways to these areas, it was decided that the activated sludge was the only method of sewage treatment that could be used.

Screens—The new outfall sewer, consisting largely of 20-in. vitrified clay pipe, laid on a 0.1% grade, follows the north side of the Merced river to a point directly opposite the treatment plant, and then



Aeration Tanks at Yosemite Valley Activated Sludge Plant

passes under the river to the plant. At the head of the siphon on the north side of the river, there is a screen chamber having two sections provided with bar screens, one 6½ by 3 ft., with 3-in. openings, and the other 6½ by 4 ft., with 2 in. between the bars. The sewage passes from the coarse screen through a narrow, vertical opening in the wall separating the two sections, and then through the second screen and out of the chamber in a 12-in. cast-iron pipe at right angles to the second screen. By this arrangement, pieces of wood and other material larger than 2 in. thickness, or longer than 12 in., cannot pass through the screen chamber to the siphon.

Pre-Settling Tank—There were constructed as part of the original sewer system four pumping stations, two on the trunk line and two on the laterals to the camp grounds. One of the pumping stations on the trunk line was abandoned when the old sewer system was extended to the new plant, and at the other 90% of the sewage is collected in a basin and raised to a higher elevation by a 6-in. centrifugal pump, capacity 850 g.p.m. Sewage is, therefore, delivered to the new treatment plant at approximately this rate and in amounts depending on the population on the floor of the valley. The new treatment plant was designed to treat sewage at a continuous rate of flow of 850 g.p.m., or 1,224,000 g.p.d. This is practically 150% more sewage than the average flow in 1931, for the month of June, which is the month when the largest volume of sewage is produced.

A covered concrete settling tank, 40 by 10 by 16½ ft. to the bottom of the hoppers, without baffles and having a theoretical detention period of 45 min. at a flow rate of 850 g.p.m. and a rate of settling of 1500 gal. per sq. ft. per day at the present maximum daily flow, was included in the design of the new treatment plant to remove the coarser solids. Baffles were omitted to prevent formation of scum which might produce odors. The sludge collected in the hoppers is drawn off once a day to a thickening tank, where it is mixed with excess sludge from the final clarifiers and after settling, the concentrated sludge is pumped to the digestion tanks.

Aeration Tanks—These tanks, four in number, are 50 by 18½ ft. and have an effective depth of 12 ft. They are the spiral flow type and arranged so that the first two can be operated either in series or as single units, or with the other two in series of three or four units. The two rows of porous plates in each tank are set over concrete channels extending the full length of the floor. The plates are supported longitudinally by the side walls of the channel, and transversely by aluminum bars, and are held in place by cement grout. The aluminum bars are $\frac{3}{16}$ by 2 by 13 in. long, and were used in place of T-bars because the galvanized-iron T-bars in the aeration tanks at the Grand Canyon treatment plant (designed by myself and others) rusted, and particles of iron penetrated the porous plates and caused clogging. The aluminum bars are much cheaper than the T-bars and are more easily installed.

Air is admitted to the ends of the channels and each air-inlet line has a connection for a recording gauge. At the ends of the air channels there are 4-in. pipes and valves which are used to let the sewage out of

the channels when air is applied. If the plates become clogged, they can be cleaned with water, or steam sprayed from a hose line pushed through the pipes and under the plates, or by solvents passed through the plates from the top surfaces to the channel below.

Two blowers, each with a normal capacity of 425 c.f.m. of free air against a total head of 6½ lb. per sq. in. at elev. 4000 ft., were included in the original plans. Later there will be installed a standby unit operated by a gasoline engine. The 850 c.f.m. of air delivered by the two blowers provides 1 cu. ft. of air per gal. of sewage when the 6-in. pump on the trunk sewer line is operating.

Clarifiers—There are two clarifiers operating in series, but designed so that they can be operated separately. No. 1 clarifier, which receives the effluent from the aeration tanks, is 28 ft. diam. and 11 ft. deep, while No. 2 has the same diameter but is only 10 ft. deep. When the treatment plant is operating at its maximum capacity, the rate of settling is 750 gal. per sq. ft. per day. The theoretical detention period during the maximum flow of sewage in the summer at the present time is 2½ hours.

Liquid chlorine is applied to the effluent of clarifier No. 1 as it passes through the channel to No. 2 unit.

The activated sludge from clarifier No. 1 is returned by an air lift to the raw sewage as it enters the aeration tanks, and the excess sludge is discharged by gravity to a thickening tank at the same time sludge is drawn from the pre-settling tank.

From clarifier No. 2, the sludge, which has been disinfected, is returned by an air lift to the pre-settling tank.

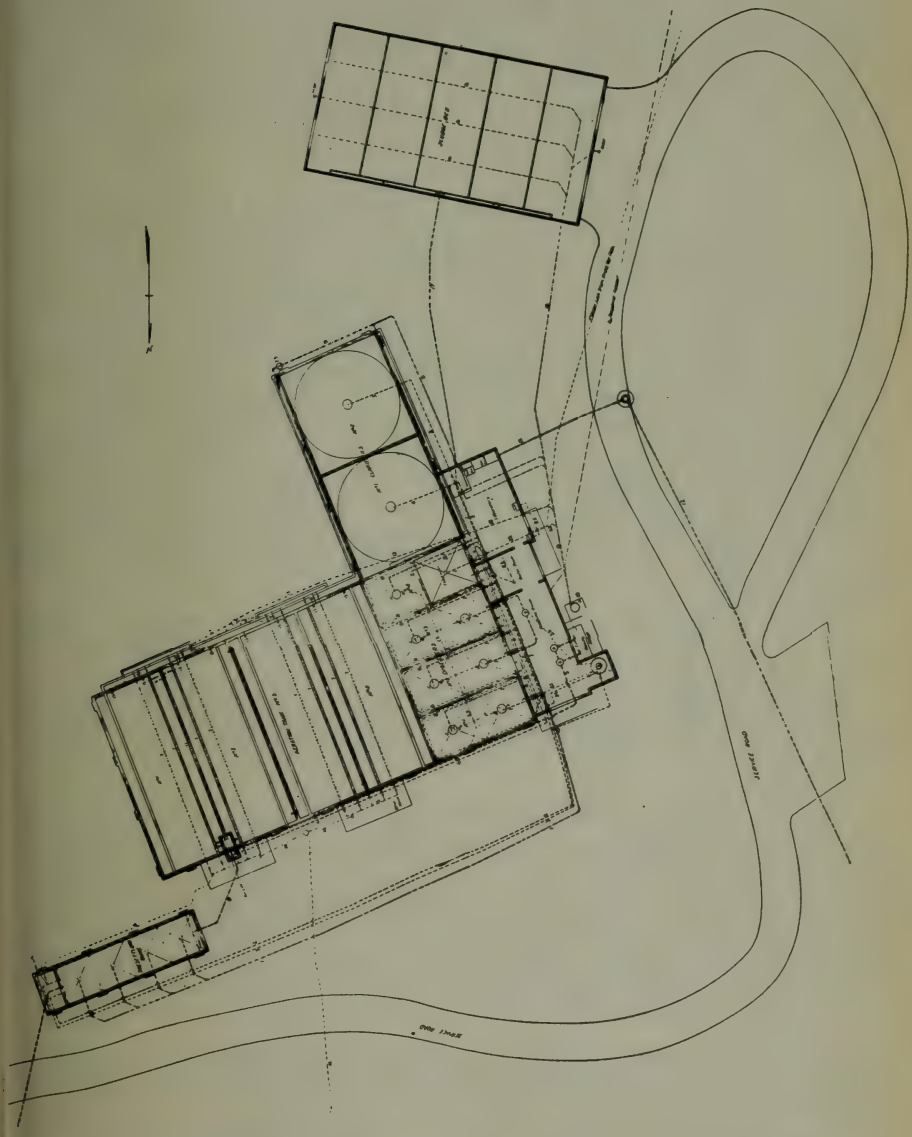
The sewage entering the clarifiers is distributed across the tanks by means of small V-notch weirs, and the effluent flows over plain knife-edge weirs. Four feet beyond the V-notch weirs are baffles, consisting of metal plates that extend to a depth of 5½ ft. below the surface of the sewage and hang from I-beams supported by the walls of the tanks.

One side wall of clarifier No. 1 is within the building housing the laboratory, heater and machinery, and in this wall there are four 2-in. sampling cocks, set 1½ ft. apart.

Disinfection—The effluent from clarifier No. 2 passes through a weir box set under the floor of the laboratory, and in one section of this box there is a float that operates a full-automatic, solution-feed chlorinator. This machine applies a uniform amount of chlorine per m.g. of effluent, regardless of fluctuations in flow of sewage.

Thickening Tank—This tank, adjacent to the digestors, is 14 by 12 by 18½ ft. to the bottom of the hopper and receives by gravity the sludge from the pre-settling tank and the excess sludge from clarifier No. 1. The sludge from these two sources is mixed together, is allowed to settle 3 hr., and the sewage is then drawn off through 3-in. pipes set 1 ft. apart in the front wall. The concentrated sludge is pumped to the digestion tanks, and the sewage drained off is pumped back to the pre-settling tank.

Sludge Digestion Tanks—The Imhoff tanks at the old treatment plant were in operation 10 years and sludge was removed in the fall of



Activated Sludge Sewage Disposal Plant for National Park Service in Yosemite Valley

each year, but no data were available as to the volume of sludge produced per m.g. of sewage treated. There were likewise no data in the literature on sewage treatment regarding the amount of sludge for a population similar to that in Yosemite valley. Since, however, it was necessary to produce well-digested sludge to prevent odors at the drying beds, the digestion tanks were designed for storage of 1.5 cu. ft. per capita for an average daily population during June, July and August of 10,000 visitors and 1400 employees, which is more sludge and a larger population than is expected. It is believed that the volume of sludge produced in the valley is only about one-half that of an equivalent population in a city.

There are three sludge digestion tanks, 28 by 12 by 18½ ft. to the bottom of the hoppers, and one tank with half the capacity of the other three. All of these tanks have fixed sloping concrete covers with concrete gas domes, and all except the smaller one have 3-in. drain lines 1½ ft. apart in the front walls, for removing sewage from the sludge. There are connected with each gas dome a sealed trap, a gas line, and a device for determining the sludge level in the tank. All of the digestion tanks are connected by means of 10-in. pipes, arranged in the form of an inverted letter U and set at an elevation that will permit sludge to flow from one tank to another whenever the sludge level rises to the bottom of the gas domes. A centrifugal pump connected with the piping system of the digestion tanks pumps the concentrated sludge from the thickner to the digesters and circulates the sludge from the hoppers to the tops of the tanks. The digested sludge will flow by gravity to the drying beds.

Coils were placed in all the digesters for heating the sludge and they are arranged so that one or any combination of tanks can be heated.

Sludge Drying Beds—For drying sludge, there was provided a glass-covered sand filter, 75 by 40 ft., which provides 0.33 sq. ft. of filter area per capita for the maximum population that may be expected in the future.

Storage Tank and Automatic Pumping Equipment—This tank is 20 by 4 by 4½ ft. deep and is used for collecting the sewage drained from channels under the porous plates, from the sludge bed, from the drain cocks in the digestion and thickening tanks, wastes from laboratory, and the sewage drained from all the tanks. A centrifugal pump, automatically controlled, pumps the sewage to the pre-settling tank. The piping system at the plant was arranged so that it is impossible for any untreated sewage to reach the river.

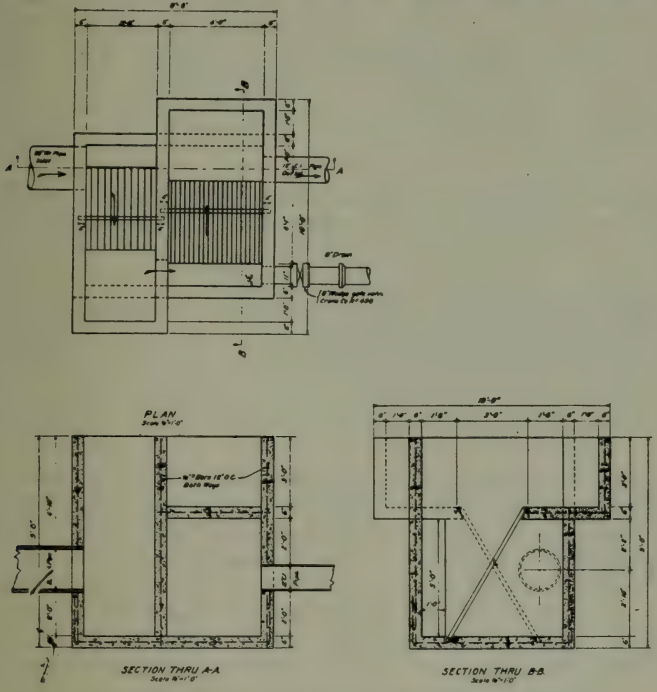
Gas Holder and Heating Equipment—A standard design of gas holder will be installed during the spring of 1932 and the temporary heating plant will be replaced.

Laboratory—A small chemical and bacteriological laboratory, an office, and a separate room for the chlorine machine are located in the building that contains the blowers, sludge pump and heating plant.

Cost of Treatment—The cost of the treatment plant, exclusive of engineering, the gas holder and heating equipment, was $61,800. The

cost of the plant per m.g. on the basis of a rated capacity of 1.22 m.g.d., was $50,650.

Operation of Plant—Sewage was turned into the plant on August 8, 1931, for a few hours, and during the following week a small amount of sewage was added daily. Although the blowers failed to operate properly and air was not applied continuously, there was on August 15, 3% of activated sludge in the aeration tank. Between August 16 and



Coarse Bar Screen for Merced River Siphon

September 6 a daily average of 45,000 gal. of sewage was applied to aeration tank No. 1 and one blower was operating almost continuously. By this time there had developed a satisfactory flow which was 19% of the volume of the aeration tank. On September 11 all of the flow of sewage, 200,000 g.p.d., was turned into the plant and aerated in unit No. 1 of the four aeration tanks. Following this date the plant has been in continuous operation, treating all the sewage produced in Yosemite valley.

Between August 8 and September 20, all the difficulties experienced in operation of the mechanical equipment were straightened out, a satisfactory floc developed in the aeration tanks that readily settled in the clarifiers, nitrification developed, and the chlorinator was adding the proper amount of chlorine to the influent to clarifier No. 2 and in proportion to the flow of sewage from the plant. The operation of the plant during this period indicated that: (1) the coarse bar-screens will remove materials that might clog the siphon under the river; (2) the

pre-settling tank will remove a large part of the coarser and heavier suspended matter; (3) the excess activated sludge, when mixed with sludge from the pre-settling tank, will lose a large part of its water; (4) the thickening tank is necessary to produce a concentrated sludge suitable for digestion; and (5) the plant as a whole is adequate in capacity to treat the volume of sewage for which it was designed.

The practical use of long channels under the porous plates in the activated sludge plant at the Grand Canyon National Park has been demonstrated in the operation of this plant during the last 5 years, and the experience with this method of applying air to the porous plates at the Yosemite valley plant to September 20 has been very satisfactory. At both plants the air is distributed uniformly throughout the entire length of the channels, and the loss of head up to the plates is negligible.

Analyses—Only a few chemical analyses of samples of the effluent were made to September 22, the average of 15 of these analyses being as follows:

Effluent, final clarifier—dissolved oxygen	6.1 p.p.m.
Effluent, final clarifier—oxygen demand	2.1 p.p.m.
Effluent, final clarifier—alkalinity	25.0 p.p.m.
Effluent, final clarifier—free chlorine	0.3 p.p.m.
Effluent, final clarifier—relative stability	99
Effluent, aeration tank—nitrates	0.21 p.p.m.
Effluent, aeration tank—settleable solids on September 20	20%

Bacteriological analyses of samples of water collected from the river above the plant showed practically the same number of B.coli per cc. as found in the river 1 mi. below, while the samples collected at the park boundary as a rule had fewer B.coli per cc. than the samples collected in the park. Hourly tests for free chlorine in the effluent from the plant were made in place of bacteriological analyses. Approximately 5 p.p.m. of chlorine is added to the influent to clarifier No. 2 and the residual in the effluent varies from 0.2 to 1.0 p.p.m.

Acknowledgments—The treatment plant was designed by me, O. C. Hopkins, assistant sanitary engineer, and A. L. Dopmeyer, past assistant sanitary engineer. Construction, including 3¼ mi. of 20-in. sewer line, was under the general supervision of F. A. Kittridge, chief engineer of the National Park Service, with Arthur E. Cowell, associate engineer, in active charge of the work between April and December, 1930, and George D. Burr, associate engineer, from April to July 1, 1931. The architectural plans for the building and exterior surfaces of the tanks were prepared by John Wosky, assistant landscape architect, under the general supervision of Thomas C. Vint, chief landscape architect of the National Park Service. The treatment plant and sewer line were constructed by force account. Jack Emmert, assistant superintendent of the park, and E. M. Hilton, park engineer, were directly responsible for purchasing materials and accounting, and all other activities connected with the construction of the treatment plant and sewer line.

I wish also to express my appreciation for the valuable information and cooperation given by C. G. Thomson, superintendent of the park.

SEWER VENTILATION, WHY AND HOW?

By D. DONALDSON*

Do sewers require ventilation? They do, for at least three reasons: (1) for the benefit of their contents, (2) for the security of their construction, and (3) for the safety of the public and the sewer maintenance crews.

Somehow in the present-day complications of engineering the simpler facts of common sense and past experience become pushed aside while we wander off into the scientific woods of argument and debate on less essential problems. It is, therefore, not to be wondered at that one monumental work on "Sewerage" of 750 pages devotes 11 lines to Ventilation of Sewers. It may be that the subject is regarded as so basically obvious that every engineer should be self-taught in its advantage, but when one studies the work done in the past few years in California and elsewhere it is definitely apparent that ventilation of sewers is one of the last things thought of, if considered at all.

Why will ventilation serve to benefit the sewer contents?—Oxygen is essential to aerobic action and its maintenance. If you close up a sewer system and only allow a limited quantity of air to filter in under adverse conditions as regards its renewal, the oxygen supply is shortly depleted and anaerobic action begins, with all of its objectionable consequences.

The superintendent of the disposal plant wants the sewage delivered to him in aerobic condition, and it is no excuse to say the distance is too great. In the fast-flowing sewer many miles long, aerobic conditions can be easily maintained by ventilation; but if it is deliberately closed up so that fresh air is no longer available, the maintenance of aerobic conditions is practically impossible. Can that be considered good engineering? You say that you have complaints of smell, and your nose confirms these. What do such conditions disclose to you? Is it the need for more ventilation or for less? Which? If you know your business the answer is easy, and you will at once proceed to let the smells out by letting the air in. There is no other answer. From 1850 on, when sewers were first installed for large projects, the question of their ventilation has been an active one. In 1857 Gurney, who had charge of heating and ventilation services of the British Houses of Parliament, where smells were too much in evidence from the adjacent Thames (at that time practically an open sewer), proposed that in the closed sewers to carry the sewage, "As the noxious gases would be confined within the sewers themselves, he recommended that special openings be made near the mouths of the sewers for burning the gases, they being inflammable when mixed in a certain ratio with atmospheric air". So that, from this early date ventilation was a recognized need and one of its possible forms was provided for.

Now in recent years you may have noticed another item of interest on ventilation, Imhoff using the open ditch wherever possible for sewage conveyance. Why? For the better maintenance of oxygen con-

*Designing Engineer of Sewers and Storm Drains, Alhambra.

tent. His later ideas on purification of the Ruhr river included pooling to obtain a greater surface contact. This is just common-sense adaptation of nature's requirements for aerobic action, which has also for assistance the health-giving sunlight.

Injury to Sewer Structures—Presuming the absence of ventilation by ignorance of its essential need, or the deliberate creation of such conditions, the sewer contents are driven along a closed tunnel in which, in terms of its length, the conditions are more adverse with every mile. In such a sewer many things may happen to sewer materials, which are no credit to the designer and in which no fault attaches to the failing materials.

In southern California thousands of dollars have been spent in a futile attempt to box up sewage, and with vain hopes that nothing will happen to the sewers. Since much did happen to them, instead of revised ideas on ventilation we find a continuance of the old closed notions plus more expensive constructions to withstand the objectionable consequences. In other words, we are fighting fresh air with dollars.

All over the world concrete has served and is serving excellently in sewers, even where the sewage is five times as concentrated as it ever will be in California. Why, therefore, does it fail here? Just for the reason so often referred to—lack of ventilation. Some of the older sewers in the city of London were, as are almost all main sewers there, built of brick, the inverts in cement mortar and the upper portions in lime mortar. Those sewers serve today, and all their new main lines are of brick in cement mortar. They show no signs of the corrosive action complained of here, because their engineers long ago realized by experience the expensive consequences of inadequate ventilation. The function of good engineering is to start from the point of highest achievement and rise still higher, not to start way down in the scale making the same old blunders over again.

Safety Measures—In all sewer services, maintenance operations are at times necessary. For the safety of workmen engaged therein, ventilation is the first and most important factor, and the design engineer who fails in unremitting attention to the safety needs of this feature, should be called before the coroner to explain the carelessness for which he is criminally liable. When the ventilation conditions of the sewer are as carefully considered and provided for as are the hydraulic conditions, the design engineer may feel he has done his duty, but not until then.

Modern conditions with the automobile and its fluid and gaseous needs have created new problems in sewer ventilation. Leakage from gas lines into sewer mains, and not infrequently the gaseous products of industrial wastes, also create new dangers. All of these have but one line of protection, which is not that of confinement, but that of release through more and more ventilation. One part gas to seven of air, or a 1½% mixture of gasoline with air, will create explosive mixtures.

Since life is the issue at question in this phase of sewer design, no apology is offered for the addition to this paper, as an appendix, of the

extremely excellent rules drawn up by Bell, engineer to the Camberwell Borough Council, London, England. Every item of these rules and their provisions should be adopted "in toto" by sewer maintenance engineers and carried out with the utmost care.

Entirely too many men have lost their lives in sewers in California, and conditions are still adverse. Until sewer ventilation and its needs are recognized, dangers will continue, and too great care of the lives of their crews cannot be exercised by those in control of maintenance.

Danger to the public also arises in an unventilated sewer filled with explosive gases. Los Angeles has had some experiences along that line and other cities as well in damage to life and property and continuing danger.

How to Ventilate Sewers—After having said so much upon the matter of ventilation and Why sewers should be ventilated, what is to be said about the How of ventilation? Air replacement is a simple issue, in its elementary forms depending largely upon temperature relations and governed by conditions of inlet and outlet. In small pipe systems if effective inlet is provided by vented manhole covers, sufficient outlet is made available by the house stacks. The American system, in which no disconnecting trap is placed upon the house lines, is much more favorably situated in this respect than is the European system where house traps are invariably used. The European system, however, has a modern leaning toward the abolition of house traps for the purpose of securing the better ventilation incident to the American system. Given this good outlet, why misuse it and prevent its being effective by refusing to supply the lower level inlet through open-top manhole covers or other equally effective inlets?

In the larger lines, conditions requiring more extended consideration in design will occur. Owing to concentrations or other features, each case must be taken up separately and from the conditions existing a cure diagnosed whereby air will be either automatically supplied —even by forced draft, if necessary. In some cases, low-level inlets with stack high-level outlets will serve. Where such conditions are not applicable, forced inlets or suction outlets must be supplied. In all cases the condition which all ventilation science aims at, namely, the required number of air changes per time unit, must be attained.

One simple criterion of a properly ventilated sewer system is the dryness of the walls of its structures. If the air changes are so frequent as to insure this, the system is effectively ventilated, and with the moisture the sulphide troubles also disappear.

The same engineer will design a tunnel and take endless pains to secure ventilation for the safety and security of the men working therein, but will pass up apparently without a thought the similar or more adverse conditions existing in a sewer (tunnel) in which also workmen will necessarily be engaged, at any time or place. When our sewers get the same attention in ventilation that tunneling receives (tunneling regulation of New York State requires 100 c.f.m. of air per man), then the problem of sewer ventilation will have been largely solved and we will not be so likely to spend time and money in expensive chemical treatments as palliatives to a condition we ourselves have

created. Stack pipes, no matter how high or how large, are useless when lacking an equal inlet service. This is a condition often forgotten, and similarly no amount of energy used in fan propulsion or suction will be effective lacking inlet service of equal capacity, at the lower point at which this can be supplied.

Some very interesting material upon stack ventilation can be obtained from the Bureau of Standards inquiry into "Minimum Requirements for Plumbing," under direction of the United States Department of Commerce. This publication can be secured for 35 cents from the Superintendent of Documents, Washington, D. C. (See also Babbitt on "Plumbing".)

It is no argument to introduce the matter of smells. One authority says: "If there are seriously objectionable odors from the manholes, such should be considered valuable as notices that the sewers are in a dangerous condition demanding immediate work to make them safe".

I have only touched the high spots of this subject in this sketchy paper. The science and history of sewer ventilation would fill many volumes, but it is hoped that the matter submitted will receive the prompt attention it deserves, not from the manner of presentation, but from its essential seriousness as a factor in public security and economy.

Regulations for Prevention of Accidents in Sewers Approved by the Camberwell Borough Council and Prepared by William Bell, Borough Engineer.

(Published in The Surveyor January 16, 1931)

1. Each gang working in a sewer, which in these instances includes also any manhole, side entrance, sump or underground chambers, shall be provided with safety lamps (oil or electric), one detector lamp (Davis Boss or other approved type), one miner's safety lamp (where electric lamps only are used), lead acetate test papers in stoppered bottle, life line, and safety sling in case.

2. Before men are allowed to enter any sewer, as many openings as possible shall be uncovered and time allowed for the air to be changed.

3. When owing to the absence of ventilation, to unusual smells, or to discharges from factories, there is any doubt as to the purity of the air in any sewer, it shall be tested before any man enters the sewer by means of (a) detector lamp, (b) test papers, in the manner described in the printed instructions supplied with them.

4. These tests shall be also carried out or repeated, if any doubt arises as to the purity of the air while men are working in the sewer or have occasion to enter it.

5. No open light or fire shall be allowed near any entrance to a sewer. No smoking shall be permitted, naked lights used, or matches struck in any sewer. No man working in any sewer shall, when in the sewer, have in his possession matches or any other means of creating a flame.

6. All oil lamps shall be lighted above ground at least 10 ft. from the sewer opening, or further, if any smell of gas or other unusual smell is noticed. No damaged lamp (oil or electric) shall be taken into any sewer. If at any time this lamp (or any oil lamp where such is in use) is found to burn freely or a cap form over the flame, the men should at once withdraw and test the air as described in paragraph 3 above.

7. The only dangerous state of the air in sewers which the above tests might fail to detect is that due to the presence of poisonous gas. This is unlikely to occur.

Should, however, any unusual smell be met with in a sewer, especially a smell of almonds, the sewer shall be immediately vacated and a report made to the superintendent or foreman.

8. In all cases where safety chains or bars exist, such chains or bars shall be fixed across the sewers at the side entrance immediately below where the men are working by the man first entering the sewer. A lighted lamp shall be fixed above the chains or bars. In cases where no chains or bars exist, struts or other efficient substitutes shall be fixed at the same place, with a lighted lamp above them.

9. No man shall enter any sewer unless there is a man stationed on top of the manhole or entrance shaft at the place from which work is to be carried out. The man shall keep in touch with the men in the sewer by calling or signaling to them, if necessary, at frequent intervals.

10. In case of any accident to men working in sewers, and additional assistance being required, the London County Council Fire Brigade shall be at once connected with by telephone.

11. The superintendent, foreman, or man in charge shall take any further precautions he may consider necessary to meet special conditions in any particular case.

12. The superintendent or foreman shall obtain the signed statement of each man employed in the sewer department that he has been supplied with a copy of these rules and has read and understands them.

13. The superintendent or foreman shall be responsible for supplying each gang with the apparatus detailed in paragraph 1 above and for the satisfactory working conditions of the various articles.

14. The superintendent or foreman shall be responsible for all apparatus referred to in these regulations being kept in good condition. Care must be taken to keep the life line and safety sling free from damp. They must be thoroughly examined at least once a month to ensure their good condition.

EXPLOSIONS IN SEWERS AND SEWER MAINTENANCE*

By W. T. KNOWLTON†

Ventilation—Air in sewers should never be stagnant, but constantly in motion. This involves air escaping at some point and being renewed at others. All impurities in the air above the sewage are thus oxidized, and the air should not differ materially from that outside.

It has been thought by some that disease germs are carried in the air within the sewer. If the sewers are well built and well ventilated, it is questionable if sewer gases spread epidemics. In summer, the air inside sewers, being cooler and heavier, will flow downward to the outlet. In winter, this air is warmer than that outside, and tends to rise. To prevent an upward current through the sewers entering the house fixtures, the latter are trapped.

It has been the general practice for many years to carry the sewer gas directly through the house-connection sewer to a point above the roof of the house. Some of the gas also finds an outlet through the holes in the manhole covers, on which account recent practice has eliminated all such holes, excepting a pick hole whereby the cover can be removed.

Where vents on bungalows are located along outfall and main sewers, as are found in Los Angeles, there has been complaint on account of gases escaping from the roof vent when the air is heavy or damp. During foggy weather the odor of hydrogen sulphide coming from these sewers has at times been obnoxious to the neighborhood. To remedy these complaints the house-connection sewers have been trapped at or near the property line.

Gas—Although sewer gas may not be deadly to human life, the air may contain other gases that are dangerous. The presence of these gases lessens the vitality and renders the human system more liable to conquest by disease germs. Should, however, gas of an explosive nature find its way into the sewers, an extremely dangerous condition may be created, which can cause serious injury or loss of life on ignition.

Leakage of illuminating gas into sewers happens occasionally and has frequently been the cause of explosions that have damaged property. Short circuits in electric wiring have at times given the spark necessary to ignite the gas. Where gas collects in sewer manholes, explosions have been caused by street cars passing over the manhole.

Gasoline—The disposal of gasoline into the sewers is a matter of vital importance to all cities, and especially in those having many garages and service stations. The discharge of gasoline into sewers can cause fires, as well as damage to the sewers, both of which are dangerous to the public welfare. In an explosion that occurred about

*Written discussion of paper by D. Donaldson, presented but not read at the meeting.
†Sanitary Engineer, Los Angeles Sewer Department.

2 years ago in Los Angeles in an intercepting sewer on Slauson ave. between Avalon blvd. and Western ave., 30 manhole covers were blown several feet into the air, some going as high as 25 ft., according to eye witnesses. Each of these covers weighed 220 lb. and several covers struck the pavement with such force that they were broken to pieces. At 9 a. m., when the explosion took place, Slauson ave. was crowded with traffic, so it was miraculous that no persons were injured nor any automobiles damaged. The possible cause of this explosion was the ignition of gasoline vapors in the sewer manholes by a city asphalt heater working along the sewer line.

Combustible Gas Indicator—As a result of the Slauson ave. explosion, the Sewer Division of the Los Angeles Bureau of Engineering obtained the use of a gas indicator from the Los Angeles Gas & Electric Corp. and made a survey of the sewer manholes on Slauson ave. and sewer lines tributary thereto. This survey indicated that in many of these manholes there were considerable quantities of explosive gas. This gas was traced to oil refineries in the adjoining city of Vernon, which city discharges its sewage into the Los Angeles system. Steps to eliminate this disposal of gasoline into the sewers adjacent to the refineries were immediately taken by the Vernon officials. Subsequent tests along these sewers have shown that although there is some gas still in evidence in the manholes, it is in greatly reduced quantities and below the explosive point.

Since the explosion in Slauson ave., the Los Angeles Sewer Division purchased a Union Carbide Co. combustible-gas indicator, which shows accurately the pecentage of combustible gases up to 20% above the lower explosive limit of such gases. The principle of operation of this indicator is based on the Wheatstone bridge equation. The current is supplied from a mine-type storage battery through a meter box to a filament, all of which are in—and part of—the indicator equipment. When this indicator is introduced into a combustible atmosphere, the combustible gas burning on the filament increases the heat of the filament and causes a change in the flow of the current through the meter, thereby moving the needle up the scale of combustible gas indication.

Survey of Gas Conditions in Sewer Manholes—Believing that the use of this indicator would enable the city of Los Angeles to have some record of where and in what quantity combustible gas was contained in its sewerage system, a series of tests for such gas has been made in the manholes of all of the larger sewers of the city, and to some extent in the smaller sewers. This survey work has covered an examination of 1500 sewer manholes during the past 18 months, and in many cases some of these manholes have been tested two or three times.

A study of the results of these tests indicated this combustible gas to vary in quantitative analyses throughout the city, and to be above the danger point in 315 locations, or 21% of the manholes examined. As, however, there are 50,000 manholes in the 2500 mi. of sewers in the city system, one can have some idea of the magnitude of testing for this gas if all manholes in the system were to be examined. It is not considered, however, that such a complete examination is necessary,

as many manholes can be omitted in sections where the survey indicates no gas to be present.

Illuminating Gas—The leakage of illuminating gas into sewers and sewer manholes has frequently been found to be the cause of explosions. Not only in California, but throughout this country and abroad, there are records of explosions due to this cause. In Los Angeles this gas has found its way recently into a sewer under construction and, when ignited in some unknown manner, completely destroyed 350 ft. of sewer, besides causing manhole covers to be blown 25 ft. into the air. Fortunately no one was present when this explosion took place. In other parts of this city, explosions have occurred from broken gas mains, which injured workmen severely, and in one case caused death. It is needless to say that the local gas companies in this city do everything in their power to prevent accidents. In fact, these companies are cooperating with the city in its work of tracing the source of gas entering the manholes.

As gas leakage may come from the breaking or cracking of a gas pipe, attention is called to the settlement in streets which takes place on account of excavations on private property. Unless there is close cooperation between those in charge of the supervision of buildings and those supervising street work, the settlement of the street may permit gas coming from such breaks to follow a filled ditch line and enter structures in the street or on private property. This settlement of street surface has occurred in Los Angeles and resulted in the breaking of utility pipes in the filled portion of the street. Arrangements are now pending to correct this condition by cooperation between the Bureau of Engineering and the Building Department of the city.

The United States Bureau of Mines has given considerable attention to the danger of combustible gases in manholes of public utilities. Six years ago this bureau conducted tests in telephone manholes in Pittsburgh and Philadelphia to determine the hazards from combustibles. The results of these tests were published in October, 1925, in a "Report of Investigations No. 2710 of Gas Hazards in Street Manholes." A recent "Report of Investigations No. 3109" was published by the United States Bureau of Mines in May, 1931, on "Gases in Manholes," being a survey of the bureau in 1929 and 1930 of the gas conditions in the manholes of the Edison Electric Illuminating Co., of Boston, Mass. During this period of about one year, 1765 different manholes were tested, 107 of which showed the presence of combustibles or sewer gas. The territory covered by the survey included 19 other cities, in addition to the city of Boston. It may be noted, however, that the manholes in the outlying districts were usually free from gas.

Odors—In conducting this survey in Boston, an odor or smell test was made of the atmosphere from each manhole, and it was noted that the smell test was positive in indicating large amounts of combustible gas, but did not give any indication of the relative amounts present. Where the majority of tests indicated a faint odor, combustibles were not present in amounts equal to 25% of the lower explosive limit.

The Boston report states that it is a very dangerous procedure to rely on odors as an indication as to whether a manhole is safe to enter.

A case is cited where there was no odor, yet the air contained only 8.2% of oxygen, which condition would have overcome a man entering such an atmosphere.

Carbon monoxide and hydrogen were present in all tests where combustibles were found to be equal in amount to 25% of the lower explosive limit. It was, therefore, concluded that leakage of manufactured gas (of which carbon monoxide and hydrogen are normal constituents) was the chief source of combustibles in the manholes. This reasoning was substantiated by the fact that when repairs were made in gas mains in the vicinity of where carbon monoxide and hydrogen were found, explosive conditions in the manholes soon disappeared. In no case were gasoline or other similar hydrocarbons detected.

London Explosions—In volume 75 of the "Surveyor and Municipal and County Engineer," issued on April 12, 1929, there is on p. 411 a condensed report of the commissioners appointed by the home secretary to inquire into the series of explosions and fires which occurred in London during December, 1928. This report states that the explosions were due to a mixture of coal gas and air, and that the gas was a gradual accumulation of leakage from neighboring gas mains extending over a considerable period and increased by some larger untraced escape within a short time of the explosion.

The commissioners recommended that all underground structures of any considerable size should be adequately and continuously ventilated, or if disused, filled in or removed. Coordination in control of underground services in London was urged.

Conclusions—The recommendations in the London report are applicable to conditions in many cities in the United States. Leakage from gas mains into underground conduits is a most frequent cause of explosions. The disposal of gasoline into sewers is not accidental, like illuminating gas, and arrangements should be made for the collection of waste oils and gasoline so their discharge into sewers may be prevented. Periodical examinations of air in sewer manholes should be included in sewer maintenance. Whenever and wherever the manhole tests indicate explosibility conditions, the coordination and cooperation of city authorities with the local gas companies should be required.

ADVANCES IN SEWER PIPE CONSTRUCTION

By A. M. RAWN*

Since about 1917, sewer pipe in this country have been generally manufactured in accordance with standards set out in A.S.T.M. specifications C 13 and 14-24, which specify materials of construction, standards of manufacture, and final product requirements. By 1917, when the specifications were compiled, the pipe manufacturing business was an important industry. Consequently, the specifications are influenced largely by the class or type of product that was then being manufactured. Probably the specifications are a representative cross-section of the best that was being produced by the industry at the time, but because the pipe then manufactured was based upon many different and empirical design standards, it is scarcely to be expected that the composite product of the manufacturers should be accurately suited to all uses.

There can be no doubt but that the A.S.T.M. specifications have had a profound and beneficial effect upon small pipe in general. A definite product was standardized, with requirements included to safeguard the purchaser against a product inferior to the standard, and with three simple but adequate tests provided which, if imposed, insured the buyer that he was securing pipe of at least the required standard. Barring some minor changes and revisions, the specifications stand today as they were written in 1917.

The fact that such a standard was provided has all too often been taken by engineers, and others in authority, as being a blanket guarantee that pipe, manufactured in accordance therewith, could be used indiscriminately, in any depth of trench, and under any sort of load, without question or danger. Such practice began to result in pipe failures and other difficulties which have led to extensive investigation of pipe loadings and foundation supports.

During 1917, when the A.S.T.M. specifications were first published as tentative, the results of some notable investigations on trench loadings and foundation supports were issued by Anson Marston, dean of engineering at Iowa State College, but it was apparently not until a number of years later that engineers began to universally accept Marston's data as representing a true cross-section of what might be expected to occur in the pipe trench. During 1924, George C. D. Lenth, consulting engineer for the Clay Products Association, published in "Engineering News-Record" an article setting out the relation of the sewer trench width, and foundation, to the load on pipe, basing his conclusions upon the Marston data.

These two outstanding works on trench loadings and pipe foundations finally began to explain why pipe failures were occurring, and since 1924, the date of the latter publication, engineers have had an increasing skepticism regarding the adequacy of A.S.T.M. specifications C 13 and 14-24.

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The difficulty seemed to be that the standard pipe strengths were too low to fulfill average requirements. This deficiency becomes apparent when a reasonable factor of safety is applied to standard pipe strengths and the result compared to a trench depth which the Marston formula indicates will produce an equal load.

Table I presumes pipe which have been constructed to exactly fulfill standard strength requirements—equated to a working load by applying a safety factor of 1.5; laid in a trench the maximum width

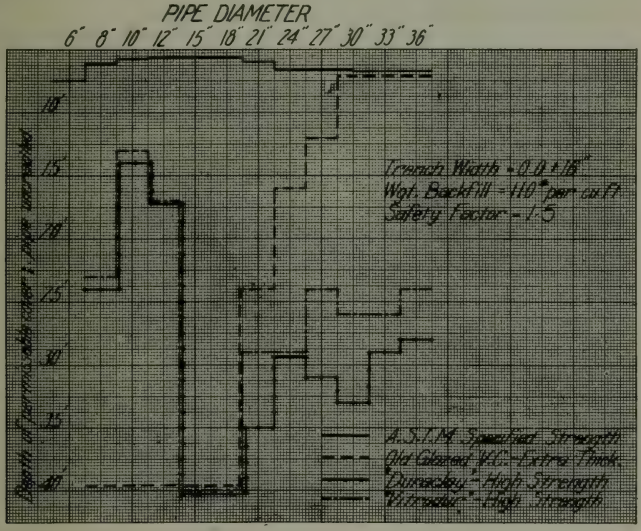
PIPE DIAMETER
6" 8" 10" 12" 15" 18" 21" 24" 27" 30" 33" 36"
Trench Width = O.D. + 16"
Wgt. Backfill = 110# per cu. Ft.
Safety Factor = 1.5
A.S.T.M. Specified Strength
Old Colored V.C. - Extra Perm.
"Duraclay" - High Strength
"Ultraclay" - High Strength

Fig. 1

of which equals the outside diameter of the pipe plus 16 in., and backfilled with saturated top soil weighing 110 lbs. per cu. ft.

TABLE I

Diam. of Pipe (in.)	Depth to Crown of Pipe (ft.)	Diam. of Pipe (in.)	Depth to Crown of Pipe (ft.)
6	7½	21	6
8	6	24	6½
10	6	27	6½
12	5½	30	6½
15	5½	33	7
18	5½	36	7

This table appears to contradict reasonable construction results, as indicated by many striking examples where pipe have been placed unsupported in trenches many times the calculated maximum safe depth, and have remained intact indefinitely. To the contrary, there have been a notable number of pipe failures under loadings which appeared to engineers well within the limits of good practice. The explanation for the wide disparity between the depths at which pipe have been found to stand intact, unsupported, can probably be found in an analysis of the pipe and foundation, rather than by any contradiction to the formula.

Nearly all pipe manufacturers make their pipe stronger by a considerable margin than A.S.T.M. specification requirements. In fact, the double-strength pipe, commonly in use at the present time, is known to have a thicker wall in both clay and concrete than the specifications require. Furthermore, care in the preparation of the trench base and in the manner and method of pipe laying and backfill exert a strong influence on the bearing capacity of the pipe. These features contribute greatly to the supporting strength of the pipe, and many times prevent failure where it would surely occur were the pipe built only to its presumptive strength and laid without care.

It is quite common practice—at least in southern California—to design pipe-lines so that the full A.S.T.M. strength of the pipe is developed in the trench, for the reason that the pipe is known to be stronger than required, and also because of care in the method of laying, supporting and backfilling.

It appears that the A.S.T.M. specifications do not specify a pipe which, unsupported, is safe for more than a portion of the lines ordinarily constructed in a community's sewer system, and such belief has resulted in an insistent demand for stronger pipe, better suited to construction needs.

Responding to, or anticipating more insistent, demands for stronger small pipe, one of the two large clay pipe manufacturers in southern California recently placed on the market an unglazed, vitrified clay pipe, which, with the exception of two sizes, can be placed unsupported in trenches more than 22 ft. deep with perfect safety. Following example, the other company is preparing to manufacture a similar product. For a number of years, one of these southern California companies has been manufacturing salt-glazed, vitrified clay pipe in dimensions from 6 to 21 in., the strength of which insured safety in trenches over 20 ft. deep.

Fig. 1 shows an analysis of permissible trench depths for four classes of vitrified clay pipe now being manufactured in the Los Angeles district, based upon the guaranteed crushing strength of each size of pipe. For the purpose of comparison, pipe which are supplied under A.S.T.M. specifications are presumed to be built exactly to specified strength requirements, although it is well known that they will exceed such strengths by nearly 50%.

There is a means for insuring the safety of a pipe of A.S.T.M. specification in a deep trench. This is accomplished by supporting the pipe in a concrete cradle of the general type described in the Lenth data, a method which has been used extensively with uniformly good results. Table II indicates the cost of cradling a specification pipe to develop the same strength as high-strength pipe. A comparison between the cost of cradling a standard pipe and installing a high-strength, unsupported pipe will direct attention to the economy of using the latter where conditions warrant.

On September 15, 1931, engineers from the city of Los Angeles, Los Angeles County, and the Los Angeles County Sanitation District departments held a conference, the purpose of which was to co-ordinate factors of design relating to unreinforced pipe, particularly vitrified clay sewer pipe. Agreement was reached that:

(a) The pipe-trench maximum width, measured at the pipe crown, should not exceed the outside diameter of the pipe, exclusive of bells and fixtures, plus 16 in.

(b) Trench loads should be calculated using 110 lb. per cu. ft. saturated top soil weight.

(c) The Marston formula, $W = C w B^2$, should be used in calculating pipe loads.

(d) A factor of safety of 1.5 should be used for the new high-strength pipe. The factor of safety for pipe manufactured to A.S.T.M. strengths was left for conclusion at a subsequent conference.

Table II has been prepared, using the above conclusions for the design basis. A factor of safety of 1.5 is applied to all classes of pipe.

TABLE II

Costs of Cradled and Uncradled Pipe in a 20-ft. Trench

	1 A.S.T.M.-strength v.c. or unreinf. cem. concrete pipe (in.)	2 Extra-strength unreinf. cement concrete pipe (in.)	3 Extra-strength glazed vitrified clay pipe (in.)	4 Extra-strength unglazed vitrified clay pipe (in.)	5 Allowable cover pipe unsupported, safety factor 1.5:1 (ft.)	6 Cost of pipe per ft. alongside trench ($)	7 Cost of cradle per ft. ($)	8 Total cost per ft. ($)	9 Saving in favor of uncradled pipe, per ft. ($)
Concrete	8				6	0.25	0.50	0.75	
		8			20+	0.37	0	0.37	0.38
Clay	8				6	0.28	0.50	0.78	
			8		20	0.32	0	0.32	0.46
				8	20+	0.35	0	0.35	0.43
Concrete	15				6	0.64	0.74	1.38	
		15			20+	0.95	0	0.95	0.43
Clay	15				6	0.85	0.74	1.59	
			15		20+	0.95	0	0.95	0.64
				15	20+	1.05		1.05	0.54
Concrete	24				6	1.56	1.10	2.66	
		24			20+	2.32	0	2.32	0.34
Clay	24				6	2.04	1.10	3.14	
			24		16	2.20	1.10	3.30	−0.16
				24	20+	2.52	0	2.52	0.62

So far, the concrete pipe manufacturers in southern California have not produced an unreinforced concrete pipe of a strength equivalent to the high-strength clay product. The figures for concrete pipe in Table II are taken from an analysis of the increased pipe thickness necessary to withstand the loadings in a 22-ft. trench, using a cost of $31 per cu. yd. for the additional concrete required in the pipe.

While the concrete pipe manufacturers have not so far endeavored to build high-strength unreinforced pipe in small diameters, there seems to be no doubt but that they will prepare themselves for competition when a fixed standard of requirement is decided upon. In this connection, the conclusions, regarding basic design data, reached at the engineers' conference in Los Angeles, are commended for study and analysis.

It is quite desirable, from the standpoint of production economy, to fix not more than two standards of pipe strengths—one to support

a trench load of about 12 and the other about 22 ft. A 12-ft. trench depth will doubtless cover 60% of all construction in the smaller sizes, and about half of all construction in the larger sizes, while the range from 12 to 22 ft. will account for nearly all of the rest. For trenches deeper than 22 ft., a concrete cradle will solve the construction problems.

The establishment of two such pipe strengths will not conflict with present A.S.T.M. specifications, because it is quite apparent from tests, that the pipe which is now being manufactured in California under A.S.T.M. requirements is not getting full credit for the strength which it will actually develop. Therefore, if the foregoing specified two classes of pipe are required, no change need be contemplated in pipe manufactured as at present, and it will only be necessary for the pipe companies to furnish a higher strength pipe (similar to that now being constructed by the southern California manufacturers) to be used in trenches where the cover is from 12 to 22 ft. The sufficiency of the pipe may still be determined by the three tests specified in A.S.T.M. standards, but there will be a double set of dimensions and strength standards instead of a single one as now. Any ordinary omissions in pipe laying or bedding will be corrected by the factor of safety.

For reinforced concrete pipe, either hand-tamped or vibrated, the A.S.T.M. has recently prepared a tentative specification, C 75-30-T, issued in 1930. This standard includes specifications for sizes from 24 to 72 in. diam., known as "standard" and "extra-strength" reinforced concrete pipe. The standard pipe is further subdivided into three groups, based upon the compressive strength of the concrete to be used in construction, the range in strength being from 2750 to 4500 lb. per sq. in. The extra-strength reinforced concrete pipe is divided into two groups, one being based on 3500 and the other 4500 lb. per sq. in. concrete compressive strength. Specifications include dimensional data; position, quantity, and class of reinforcement; and prescribed loads to produce 0.01-in. crack and failure. It seems scarcely likely that the specifications will be followed in their entirety by pipe manufacturers, as each size of pipe usually requires three sets of forms.

As a rule, the sanitary engineer in southern California is interested in reinforced concrete pipe which is lined with vitrified clay blocks. The unglazed, high-strength, vitrified clay which is used in the construction of the high-strength vitrified clay pipe is admirably suited for such use. It has a double advantage: first, its absorption is about one-half that specified for first-quality clay pipe (or about 4%), and secondly, the absence of the salt glaze permits a much better bond between the clay and concrete, thus insuring a stronger overall structure. The concrete pipe companies have, for years, manufactured a clay-lined reinforced concrete pipe, for sewer work, which has admirably served its purpose. Special improvements in this class of pipe in recent years include: better quality of the unglazed liner, a closer matching of the liner blocks, and higher strength of concrete due to advanced methods in settling the concrete in the pipe form, by vibrating the form as the concrete is placed. Recently, concrete pipe companies have signified their intention of increasing the shell thickness

of lined pipe to compensate for the loss of thickness in the crown of the pipe, due to inclusion of the liner block.

Many designers are now specifying that pipe be purchased on "D-load" requirements. The D-load is the load which the pipe will sustain per foot of length, divided by the internal diameter of the pipe in feet. A specification stating the strength requirements in D-loading without reference to the amount and placement of reinforcement or the strength of materials to be used, places the responsibility upon the manufacturer, who may then use his materials and equipment to his best advantage. For this reason, the specification is advantageous and in the interests of economy.

Under D-load requirements, some designers are insisting that reinforced pipe shall develop the required strength in test, without showing any crack at all; while others specify that strength shall be developed at 0.01-in. crack, the latter on the assumption that the crack must be reached before reinforcement actually comes into play, and therefore, even at this crack, a high factor of safety is provided by the strength of the steel. It is doubtful that a reinforced concrete pipe will show greater than 10 to 15% more strength at first crack than an unreinforced pipe of the same dimensions following which the reinforced pipe may rely upon nearly the full strength of the steel to support it against failure. If this is so, the first crack is of little importance, other than that it may admit moisture to the steel and start corrosive action. It is my opinion that the longer the pipe is in place, the greater supporting strength it derives from the surrounding backfill, and that even though the steel in a reinforced concrete pipe should be subjected to corrosive action through oxidation or otherwise, there is little danger of pipe failure as a result of the 0.01-in. crack at specified load, because as the strength of the steel diminishes, other supporting factors are increasing.

Centrifugally-spun concrete pipe has made great advance, from a construction standpoint, in the past two or three years, and while not universally used as a sewer pipe, it has many advantages which commend it to the attention of the sanitary engineer. The flexibility inherent in its construction permits the ready manufacture of a pipe of almost any desired thickness or strength. The method of placing reinforcement permits it to be designed for external as easily as internal pressures. It is manufactured in long sections without bells, which admits of economy in installation. Finally, it consists of a dense, relatively impervious, strong, durable concrete in which the reinforcement is well embedded, all of which features permit of economy in dimensions to obtain given strengths. In price, it compares favorably with the small-diameter pipes embedded in concrete, and there is no question but that its installation is more economical from a construction standpoint than such a combination.

In general, the pipe manufacturing business has increased the quality of its products at a commendable rate, outstripping specifications, and in many instances anticipating the needs and wishes of engineers. Practice in this respect calls for a prompt response from engineers in the form of standardized specifications that will be accepted as a common yardstick by all interested purchasers.

CONTROL OF CANNERY ODORS AT MONTEREY

By H. D. SEVERANCE*

Monterey has ten sardine canneries and one municipal rose garden. The canneries seem to hold the vital interests of those who labor or trade; the rose garden the rather passive enthusiasm of those who neither toil nor spin. The unpleasantness of the one is tolerated or condoned by those sustained by it in their eagerness to secure wages and profits. The pleasantness of the other is lost to those who do not have or spare the time for its intimate contact or observation. The one spreads its odor a mile or two; the other spreads its fragrance perhaps a yard or two. The one was developed by the method of trial and error through a period of 30 years, while the other was developed by the same method through a period of 10,000 years. Wherefore, let us be patient.

Monterey was a whaling station at one time, but I find nothing in the archives to indicate a very strong public sentiment in reference to odor matters. This accounts for the traditional tolerance of our native stock. In fact, an old-timer, speaking as to healthfulness of the trade, told me that the rendering of blubber on the kitchen stove would prevent anything but a large family.

About 1901 marked the beginnings of our sardine industry. The primary purpose was the canning of fish, some 500 cases being the first annual output. Now we produce 1,500,000 cases. During war time it was discovered that the waste, or by-products, offered greater profits than the canning of fish for food. Then began the rush on the part of all hands to install reduction plants to take care of the waste products, cuttings, and so forth, which were in the early stages practically thrown away. It is significant that while the canneries were not particularly sweet-smelling establishments prior to this time, there was little annoyance to the citizens generally over the town, since the odors were local and did not travel far. Except during the stay of a reduction ship in our harbor, which was evidently carrying on experiments for the production of atrocious smells, no serious annoyance was created until the installation of high-temperature rotary driers. Real trouble was in the air in and about town when all the plants were working to and beyond capacity with machinery that was breaking down, with the resulting burning of the fish meal. We began to wonder if this was all necessary, and finally decided to stop the whole business.

Well, how do municipalities put a stop to such nuisances, anyway? By passing an ordinance, of course. This was done. Ordinance No. 106 says, "It shall be unlawful for any person, firm, or corporation to suffer, allow, or permit any unwholesome, offensive, disagreeable, nauseous, or obnoxious smells, odors, or gases to arise, emit, escape, or be discharged from any fish cannery, fertilizer works, or other works, or other establishments within the corporate limits of the city of Monterey."

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That did the trick so far as the record was concerned. Anyhow, that's all that could be reasonably expected from a legislative body. But, we were still annoyed and nauseated, and were acquiring a bad reputation abroad. We, as enforcement officers, hesitated to go into a man's cannery and accuse him of producing bad odors. We would get into an argument and the chances were good that we would apologize and leave, convinced that the bad odor must come from the other nine canneries. This merry-go-round was indulged in for several years, with no noticeable cessation of odor.

I pause here for a moment to ponder the reaction of the public so far as enforcement of ordinances and laws is concerned. We are all more or less agreed that the law against counterfeiting must be enforced. As to most all other laws there seems to be a wide diversity of opinion. In the case under discussion, we observed that at the beginning of the canning season, after, perhaps, a spell of rather dull times, we would come downtown in the morning and discover that the canneries were in operation. This was not announced by whistles, or word of mouth, or by the press. We would smell it! The following reactions were noted (of course there were exceptions): Laborers said, "Hurrah"; bankers smiled; hotelkeepers swore—some of them in several languages; the Salvation Army thanked God; the merchants said, "Not so bad"; editors wrote scathing editorials; retired business and professional men sought opportunities to address the service clubs; tourists said, "Let's go"; enforcement officers wore a "what next" look similar to that on the faces of people during an earthquake. It appears generally that the enforcement of law seems to bear a certain indefinite relation to the center of gravity of public opinion.

Eventually, however, the cannery operators themselves felt the call of conscience (even a pirate has to have a conscience to be half a hero) and suggested that, if a means of destroying these odors was found, they would gladly abide by the findings. This suggestion was hailed with delight and a courier was at once despatched to the great city in search of a prophet to lead us out of the wilderness. Such a one was readily found. The city is a great place for prophets. (A prophet is one whom we call from a foreign land to confirm our own suspicions.) This prophet wisely declined to commit himself until he had been on the ground some time and indulged in many conferences with the natives. Along about Christmas time, 1927, however, he did proclaim the cause of a very great measure of our grief to come from burning fish-meal in the rotary dryers. Many other proclamations and words of wisdom were uttered by this prophet. It required another two years for all hands to be convinced of the genuineness of his findings, so in the latter part of 1929 the council did ordain again: first, to create the office of cannery inspector; and, later, to require thermostatic control of all fish-meal drying apparatus, together with a recording thermograph instrument, so that the inspector might observe the time when burning temperatures were attained in the dryers. This was done to guard us at times when the inspector might have a cold.

Two more years rolled around and at the close of last season the council again ordained, making it mandatory for those who engage in the business of running fertilizer plants to first obtain a permit so to

do from the health officer. The application for permit must describe the apparatus to be used and the means for odor control used in connection therewith. The permit is withheld by the health officer unless satisfactory means of such control is installed. The permit is revocable in case the apparatus does not function satisfactorily. The operator who proceeds without a permit violates the ordinance. The finest feature of this ordinance lies in its administration; to-wit, the county health officer is made the enforcement officer. If anything goes wrong, we can still pin it on the other fellow! We don't want our local health officer to become disliked.

Summing up our attainments over the 30 years of "trial and error," we find that both the operators and the public recognize the economic impossibility of operating fish canneries which will not carry at least a fishy odor in and about them. But, it is further agreed that it is unnecessary to maintain dryers that load the atmosphere with nauseous gases. The operators admit that something can be done and are willing to co-operate, and the patient public now demands the abatement of this unnecessary and costly nuisance. Canneries contribute materially to our economic welfare, but we cannot afford to be driven from our homes or suffer the embarrassment of having our guests asphyxiated.

Now, let's view the situation "as is" and see what's being done, keeping in mind the present economic possibility of odor elimination, which does not include local odors arising from frying and drying of fish to be canned, odor of decaying fish, steam from presses, odor of products, and odor of fresh fish. These, as a matter of pride on the part of the operators, will be kept down by keeping their canneries clean.

Odorless drying equipment has been provided at one cannery by the installation of steam-jacketed batch dryers. These dryers consist of horizontal cylinders, with a central longitudinal shaft for operating paddles which lift and stir the meal. The steam jacket heats the meal and evaporates the contained moisture, which is drawn off through a condenser under a 2-in. vacuum. No nuisance is created by this method, because there is no burning or scorching of meal.

The other so-called odorless process is what is known as the Peebles process, which involves the use of superheated steam at about 600° F., driven through a rotary dryer. The water-laden vapor discharged at the outlet end of the dryer is passed through a condenser which removes the water absorbed from the meal. It then passes through the heater, where it is boosted again to 600° F., and again passes on its way through the dryer. Very little, if any, nuisance arises from this plant, except, perhaps, the small amount of vapor arising from the condenser products, which may be destroyed by the introduction of chlorine into the steam. Here again we have no great chance of scorching the meal.

This leaves the problem of the direct or semi-direct-fired rotary dryer, in which the products of combustion of a furnace pass through and directly contact the meal. In defense of this mechanism it is claimed that if all conditions are right no bad odors result, but so many elements enter to upset the perfect balance required—such as interruption of power, mechanical troubles and breakdown, burner troubles, overloading and irregular feeding due to untrained help, irregular press operation, soft fish, etc., etc.—that perfection is almost never attained.

Instead of allowing the gases from these dryers to burden our atmosphere by way of stacks, we pass them through condensers where the scrubbing process eliminates 90% of the odor. This is quite an improvement, as it leaves more air for breathing purposes about town. The introduction of chlorine gas along the line between the preliminary and final condensation is suggested as a further step toward perfection. That is to say, in case chlorine gas is used, it is found to function very much better as a deodorizer if admitted with a water-bearing vapor instead of a completely dehydrated vapor. This is for the reason that the chlorine on contacting with the water by a simple process of chemical combination forms hydrochloric acid and nascent oxygen, and nascent oxygen has an ardent affinity for the nauseous nitrogen compounds. Therefore, the process of oxidation is promoted by introducing chlorine between the preliminary and final dehydration. This chlorination process may follow in time, as our population becomes more discriminating.

Ozone has been, and is now, I think, used in one plant as a deodorizer in connection with the scrubber, but I feel inclined to believe that ozone may be classed as a veiler and not a destroyer of odors. Oil of cinnamon would be cheaper and better.

One other manner of producing noxious gases is that of blowing oil. This is an oxidizing process for making a quick-drying oil for the paint trade, and is accomplished by blowing air through fish oil which has been heated to 250° F. The gas which is evolved from the oil-blowing process will quickly kill any pedigreed dog; therefore, vapors from oil-blowing kettles should always be burned in a furnace and never be allowed to escape in a civilized community.

LEGAL AND OTHER CONSIDERATIONS ON SEWER RENTAL

By WM. J. LOCKE*

I have been asked to speak on this subject because of a tentative opinion submitted to some of your members a year ago relative to the right of a municipality to collect rental charges for the use of a sanitary sewer. The matter was brought up on account of a decision of our supreme court in a suit brought by the city of Madera back in 1910. The city of Madera had been imposing a rental charge on its property owners for the use of a sewer which had been constructed out of money raised by a general-obligation bond issue.

An examination of technical works on sewage disposal discloses the fact that the early writers have devoted most of their attention to the engineering phases of the subject, with no information as to how the first sewer systems were financed, or whether they were constructed by public or private authorities. However, from references contained in some of the old works it appears that the first sewer systems, such as they were, were installed under the cooperative plan, each property owner contributing a portion of the expense.

An examination of court decisions in this country discloses the fact that it was not at all uncommon in various parts of the United States for sewer systems to be installed by private companies and financed by charges imposed against the users. As late as 1924, we find record of a decision handed down by the supreme court of the United States in a case entitled City of Opelika v. Opelika Sewer Co., holding that the city named had no right to regulate the prices charged by the private sewer company. Another interesting decision was rendered in the state of New Jersey and reported in volume 105 of the "Atlantic Reporter," p. 209. It is known as the Collingswood case, and the principal point decided was to the effect that an ordinance giving consent to the construction of a sewer system by a private company and fixing the maximum rates to be charged did not constitute a contract which the public utility commission might not ignore later by changing and increasing the rates. The only cases called to my attention here in California where the sewer systems were owned and operated by a private company were in the city of Madera and the town of Walnut Creek.

In 1908 a private corporation, the Madera Sewage Co., owned a system of sewers extending over some of the public streets of the city of Madera. The city decided to acquire and construct a sewer system to be operated by the city itself. In pursuance of this plan it issued and sold city bonds to the amount of $25,000. In 1909, with the proceeds from sale of the bonds, it purchased the sewer system of the Madera Sewerage Co. for $18,000 and with the money remaining constructed required extensions.

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In November, 1909, it adopted an ordinance imposing monthly charges for the use of and connection with said sewers upon all persons having property so connected. It collected charges so imposed and placed the money in its treasury to the credit of what was known as the "Sewer Fund." The total amount so received from November, 1909, to July 20, 1916, was $40,734. Of this money, $21,775 was transferred to the Sewer Bond Redemption and Interest Fund, to pay the interest and principal on the sewer bonds. The rental, $8615, was expended in some manner not specified in the record; the court thought it might have been expended for operating and maintaining the sewer. For the fiscal year ending June 3, 1915, the city collected $7253 in sewer rates, and about the same amount in 1916. A party by the name of Black disputed the city's right to collect rentals under the circumstances and the matter was taken to court, with the result that while the city was upheld in the lower court the decision was reversed by the supreme court. The city placed its reliance on an Oakland case, entitled In re Zhizhuzza, 147 Cal. 328, in which the court held that an ordinance of the city of Oakland was valid which sustained the city's right to have exclusive control over the collection of garbage and fix the sum per month which residents should pay for the service. The supreme court held the ordinance to be a valid police regulation for the protection of public health. However, in its decision reversing the lower court in the Madera case, the supreme court said:

"It is obvious that the power vested in a city of the sixth class to construct sewers does not include authority to raise revenue for general purposes by means of a toll or tax for the privilege of using the sewer. Such means of raising revenue is so unusual and extraordinary that it cannot be implied from the general grant of power to lay and maintain sewers. It may be that the power to maintain a sewer may carry by implication the additional power to levy a monthly charge to raise money for the repairs and upkeep of such a sewer. But, the rates here imposed upon sewer users were obviously for purposes additional to that of paying the expenses of repairs and maintenance. The facts found by the court below show this conclusively. Substantially the same sewer rates have been collected by the city continuously ever since the year 1909. The total amount collected was over $40,000, more than three-quarters of which was transferred to other funds and used for purposes other than the repair of sewers and their maintenance. If any of it was used for extensions to the system such use was unlawful, for the city had no power to impose taxes or tolls on those using the sewer in order to obtain money to build sewers in other streets."

I am not aware of any provision of the constitution or general laws of the state which would prohibit a municipality from permitting a private company to install sewers in a city and impose charges for the use thereof, or to prohibit the city itself from so doing. There may be some doubt as to the policy of such a practice, conceding that it would be lawful. The installation and operation of sewer systems directly and vitally concern the protection of public health, and as such may be deemed a governmental function of the highest order. It is of vital concern to every man, woman and child in the community. Therefore, it may be contended that sewers should be installed and maintained as a public enterprise, and be supported by general taxation, rather than by levying fees or tolls on those actually using them.

There would be one significant and important exception, and that is where the sewers are subjected to extraordinary or special uses,

such as carrying away the effluent of industrial plants, which either have an extraordinary amount of waste, or waste of a character which impairs the operation of the disposal works. In such cases there would be reasonable ground for imposing and collecting extra charges for use of the system, or requiring such industrial works to provide their own disposal systems, and properly treat the waste at their own expense before running it into the public system, so that they would no longer have the effect of impairing the operation of the public sewers.

Another exception would apply to cases where the owners of property are taxed for the maintenance of a sanitary district on the ad valorem basis.

It is my opinion that if a law were placed on our statute books empowering local authorities to impose and collect extra charges in such cases, the courts would be inclined to uphold it. As a matter of fact, I believe you might even go so far as to provide for the allocation of a portion of the revenues from such sources to a special fund to be used for research and experimental purposes on the general problem of handling the disposition of industrial wastes.

SEWAGE DISPOSAL OUT OF CALIFORNIA

By CLYDE C. KENNEDY*

During the months of June and July I made a trip of 9000 mi. by automobile, which covered all of the United States west of Pennsylvania and north of the Mason-Dixon line. In the course of this trip I visited most of the sewage treatment plants constructed during the past 3 years, as well as a number which I had previously visited.

In the time which I have at my disposal, it would not be possible for me to give a detailed description of the various plants visited, nor would it be of any particular interest to you were I to attempt to do so. I shall, therefore, restrict my paper to a review of the general impressions which I obtained as to the trend of practice in sewage treatment processes and as to the factors influencing sewage treatment in the territory between the Allegheny and the Rocky mountains.

Relation Between Sewage Disposal and Water Supply—Two years of deficient rainfall throughout the middle west have resulted in focusing the attention of public officials, and the public generally, on the close relationship existing between sewage disposal and water supply. Cities which have heretofore relied on surface streams as a source of water supply, have experienced difficulties in the production of potable water, hitherto unknown to them. Municipalities which have depended upon underground sources for water supply have been forced to greatly curtail the usage of water, and many are looking forward to the necessity at an early date of substituting surface waters for underground waters as supply sources. With record low flows in practically every stream throughout this territory, the effect of untreated industrial wastes in streams used for water supply has been more marked than ever before. Water purification plants, which have not been designed to operate under prevailing existing conditions of sewage and industrial waste dilution, have given unsatisfactory results for considerable periods of time. These troubles have been due to various causes. The high percentage of organic matter in the water, coupled with high temperatures, has produced unprecedented growths of algae. The unoxidized organic wastes themselves, together with the algaeal growths, have resulted in water very disagreeable in taste and odor.

The popular criticism, which has been the outgrowth of the production of water of unsatisfactory quality, has led to the calling of a number of conferences of public officials, looking toward a comprehensive program for the elimination of stream pollution. There is a general recognition of the necessity for adequate sewage treatment as a necessary adjunct to the preservation of streams in such condition that the water can be treated so as to produce a satisfactory public water supply. Notable among these conferences was the joint conference between the state health boards of Indiana and Illinois, looking toward complete elimination of the discharge of untreated sewage into the Wabash river or any of its tributaries.

The few modern sewage treatment plants which are in operation have justified their construction, during this critical season, to a re-

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markable degree. For example: The sewage treatment plant at Indianapolis, which is one of the earlier activated sludge plants, was, during the month of July, discharging in excess of 50 c.f.s. of treated sewage into White river, which below the point of discharge was carrying a flow of less than 150 c.f.s. The stream was in excellent condition. As I had seen this stream just prior to construction of the sewage treatment plant, when conditions of flow were far less critical, it was easy for me to realize that a miracle of science had transformed it. As I have said, however, this is one of the few modern plants, but its influence on the program of pollution abatement will doubtless be tremendous.

Cannery wastes there, as in California, create serious problems. During the time of my visit, pea canning operations were in full sway. I visited one beautiful picnic spot in central Indiana which I had known 25 years ago. It was a lovely gorge in solid limestone in a natural grove of native trees. Imagine my disappointment on revisiting this spot to find the entire stream the color and apparent consistency of pea soup. Fish life had been destroyed and the beautiful boating and swimming channel turned to an unpleasant-looking, ill-smelling pond.

Packing House Wastes—Interesting among the plants visited was that at Austin, Minn., of the Hormel Packing Co., for the treatment, by chemical processes, of packing-house wastes. This plant has been described in the technical journals and an account of its operation is contained in the July, 1931, issue of the "Sewage Works Journal." I will not, therefore, attempt to describe the plant, except to state that the process of treatment employed by the Hormel Co. involves the use of chlorine as a coagulant and the reclamation, on a commercial scale, of the values in the coagulated material. An interesting feature of this plant is that, while the discharged effluent has a B.O.D. in excess of 200 p.p.m., this demand is exerted so slowly that the Cedar river, below the plant, gradually improves in quality while the oxidation process is going on. Incidentally, it may be noted that Cedar river, into which this plant discharges, is the source of water supply for the city of Cedar Rapids, Iowa, which for months past has been experiencing great difficulty in producing a satisfactory water.

Treatment Processes—The outstanding development in sewage treatment practice, since my last visit to that section, was the almost universal adoption of separate sludge digestion, supplanting in nearly all the later plants the Imhoff tank. This was particularly noticeable in the plants designed by engineers who had heretofore appeared to be quite partial to the Imhoff tank for primary clarification and sludge digestion.

The activated sludge process for secondary treatment continues to grow in favor, although I do not find evidence that practice in that territory was in any respect ahead of the practice in California.

Peoria Plant—The new plant at Peoria, Illinois, represents an expenditure of about one and three-quarter million dollars to care for a sewage flow of approximately 12 m.g.d. Obviously the engineer was not forced to economize, as are most of the engineers in California, in

plant design. The various units are widely separated, with long galleries and elaborate piping systems, with every mechanical device of the very highest type. The beautiful buildings and spacious grounds made the plant very impressive in appearance, although I do not see any reason to assume that the results which are being secured there cannot be duplicated in the newer plants in California.

As an interesting detail in connection with the Peoria plant, a 75-ft. circular filter, with revolving distribution arms, has been installed for experimental work to determine its efficiency in comparison with the activated sludge unit on industrial wastes from the General Chemical Products Co. plant, nearby. This installation has a particular interest to me since, in the Phoenix plant, careful consideration was given to the feasibility of installing this type of filter there in lieu of activated sludge. I found rather a widespread interest in this type of distribution among engineers around Chicago and I am confident that it will be accepted for use in many plants of smaller capacity in the future. It seems particularly adapted to the climatic conditions which prevail in California and its use will, most certainly, eliminate a great deal of the popular objection to filters, which has been caused by the dissemination of odors from sprinkling nozzles. I visited the plant at Lebanon, Indiana, where two of these filters have been in operation for a number of years. Results obtained there were very satisfactory and comparable to the results obtained at Pontiac, Michigan, which a member of my staff visited last spring.

Plant Beautification—The outstanding feature of the new plants in the middle west is the increased importance which has been attached to the architectural and landscape features about the plant. There is a concerted effort being made to bring about an architectural treatment of sewage works which will make them comparable in appearance to works for the supply of water. In this particular respect there can be no doubt that we, in California, have been far outstripped in most cases. Along with the development of improved architectural appearance of treatment plants has developed the practice of housing most or all of the plant units. This practice takes away, in large measure, any unpleasant suggestion and makes the plants very pleasing in appearance. Of particular interest, in this respect, are the plants at Oak Park and Aurora, Illinois. Every effort is being made to popularize the sewage treatment plants by erection of signs inviting the public to visit the plants, by the installation of a visitors' register, and by placing explanatory notices and placards about the plants explaining the functions and capacities of the various units.

At the Urbana-Champaign plant a pond has been constructed, into which a portion of the final effluent has been discharged. In this pond are grown all of the species of game fish of that territory, such as bass, perch and sunfish, to demonstrate the efficiency of the process and its effect in purifying the streams.

There can be no doubt that a program of architectural treatment, landscaping grounds and popularizing of sewage treatment plants, by the methods I have enumerated, will prove one of the best means of promoting the extension of sewage treatment.

SEWAGE DISPOSAL OUT OF CALIFORNIA

By WILLIAM A. ALLEN*

It was my privilege during June and July of this year to visit several of the well known plants in the east. My particular interest was the operation and results being obtained by the various plants using the activated sludge method of sewage treatment. My observations were, of course, visual and the comments made are in no sense intended as criticism. It is rather my intention to depict conditions from an operator's viewpoint as I saw them.

Springfield Plant—I first visited the activated-sludge separate sludge digestion plant operated by the Springfield Sanitary District, Springfield, Illinois. The population served by this plant is 75,000. The present flow is 7.5 m.g.d., all of which is passed through grit chambers and preliminary settling tanks. Of this flow 3.0 m.g.d. is passed to the aeration tanks and clarifiers, the remaining 4.5 m.g.d. being by-passed to the river. The effluent from the clarifiers and the untreated sewage flow through a common line to the river to effect some dilution. The excess solids from the treatment tanks and the settlings from the preliminary tanks are digested and dried on beds. Four digestion tanks are used, two open and two with Downes floating covers. One-fourth of the drying-bed area is glass-covered. No objectionable odors were noticeable from either the digestion tanks or beds. The sludge from the drying bed is given away to people who come to the plant and remove it themselves. The clarifier effluent was very clear but contained considerable light floc in suspension. Additional aeration units and clarifiers are now under construction to permit treatment of the entire flow.

At the Indianapolis, Indiana, plant investigations are being carried on to determine the most efficient spacing and arrangement of the porous plates in the aeration tanks. Judging from the appearance of the tanks they had placed in service a short time ago, very good results were being obtained. The general appearance of the clarifiers and the effluent at the time of my visit was not very good, the effluent being quite cloudy. The effluent empties directly into the river, where considerable dilution is obtained, and it is probable that on this account better clarification is not necessary. The sewage flow is 40 m.g.d. Air consumption is 1.25 to 1.5 cu. ft. per gal., with 7 hr. detention in the aeration tanks. An American filter and rotary dryers have been installed for sludge dewatering. This equipment was not operating at the time of my visit, but I was informed that it had been operated for a short period.

The Rockville Center, Long Island, plant is using porous tubes, suspended one-half the depth of the tanks, for aeration. I was informed that 2 cu. ft. of air per gal. was used, but at the time of my visit 3 to 3½ cu. ft. of air was being used. The aeration appeared rather spotted, some tubes apparently aerating well and others poorly, resulting in

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what seemed to me a poor distribution of air. Water under 70-lb. pressure is used to backwash the tubes to prevent clogging. The effluent from the clarifiers was very poor at the time I visited the plant. Color tests made by the plant superintendent indicate considerable short circuiting. The color tests showed as much as 50% less detention on some of the units than the design capacity. This plant is located in a high-class residential district and the grounds are well laid out. Pre-chlorination is being practiced to eliminate any odors.

The Salem, Ohio, plant, treating a sewage flow of 0.8 to 1.0 m.g.d., consists of mechanical bar screens, preliminary settling tanks, aeration, two stages of clarification, and separate sludge digestion. At the time of my visit, considerable difficulty had been experienced with industrial wastes. The effluent from the secondary clarifiers was quite cloudy and contained considerable light particles in suspension. The effluent, I was informed, was considerably below normal, due to the waste coming into the plant. Spiral-flow aeration is used and the air has been reduced to 0.6 cu. ft. per gal. The detention period in the presettling tank is 2½ hr., accomplishing 60 to 70% solids removal. The detention period in the aeration tanks is 5 hr.

The Peoria, Illinois, plant is a new plant designed by Pearse, Greeley & Hansen. The plant is exceptionally well designed from an operator's viewpoint, providing unusual flexibility of operation and control. Considerable thought was given the matter of standby equipment, so that there is small chance of any shutdown being necessary for repairs to equipment. The plant is operated by the Greater Peoria Sanitary & Sewage Disposal District. The population served is 100,000. The plant is designed for 22 m.g.d. flow, although the present flow is 9 m.g.d. The industrial load has not been turned in as yet, provision being made to handle this load more or less separately if necessary. With present flow, the preliminary settling tanks have a detention period of about 3 hr. 40 min. and the aeration tanks 7 hr. 30 min., using 1.5 cu. ft. of air per gal. The ratio of porous plates to surface area is 1:11½. Gas production to date indicates 1.25 cu. ft. of gas per capita, this gas being used to heat the digestion tanks and buildings. The sludge in the digestion tank is maintained at 90°F. The effluent from the clarifiers was very good.

Milwaukee, Wisconsin, is planning to enlarge its plant to twice the present capacity. It is still found necessary to bypass some of the sewage into the lake, as the plant has not sufficient capacity to treat the entire flow. Additional dryers have been installed, and are of the same type as the remodeled Atlas dryers originally installed. Suction-type mechanisms have been installed in some of the clarifiers, but I could not obtain much information as to the relative merits of the two types in use. Information on this subject will probably be available at a later date.

At the North Side Plant, Chicago, Illinois, I was particularly interested in their method for determining the sludge level in the clarifiers. This consists of a series of small air lifts pumping from various depths, so that it is apparent at a glance what the sludge level is. These air

lifts are located in each clarifier along a center walk. This method seems to me a decided advantage over the sampling rod and bottles commonly used.

Conclusions—Summing up the observations made, it is apparent that in some cases local requirements do not necessitate as high a degree of clarification as it is endeavored to maintain at most California plants.

This is in a large measure probably due to practically all of the plants being located near a body of water into which the effluent is emptied, the dilution being sufficient to complete whatever further purification is necessary.

Except in the cases of Indianapolis and Milwaukee, sludge digestion and air drying is used as a means of sludge disposal with satisfactory results.

In general, the laboratories and equipment are superior to those in California. This, of course, is due in some cases to the size of the plant, but even taking this into consideration there is no doubt opportunity for improvement at a good many of our plants.

Buildings and grounds are very attractive in appearance and equipment is well maintained.

More thought is being given the matter of building plants with sufficient capacity for more than the present requirements, Peoria, Illinois, being a splendid example of this trend.

RECENT STUDIES ON SLUDGE DIGESTION

By A. J. FISCHER*

Advances in sludge digestion during the past year have shown a further trend toward separate digestion methods for both large and small plants. Particular attention has been given to a study of the design of digestion units to best advantage. These studies involve the question of effect of temperature control, pH adjustment, stirring, ripe sludge balance, sludge concentration, and character and quantity of material to be digested.

Former methods of figuring digester capacities on a per capita basis are now being discarded in favor of the more logical method of taking the organic load as the determining factor. It is obviously unfair to expect a tank treating all the sludge from a complete treatment system to perform the same work as a unit of the same capacity receiving only primary sludge; nor can a tank handling such materials as cannery or creamery wastes be compared with one receiving only sludge from a strictly domestic sewage.

Functions of Digester—In considering digestion capacities it should be borne in mind that a digester has three functions: (1) To produce a relatively stable and inoffensive digested sludge; (2) to produce a clear overflow liquor of low solids content; and (3) to store digested sludge until it can be drawn onto drying beds. As a rule, the natural separation of water from sludge during the process of digestion is enough to provide a sufficiently large clarification zone to allow the displacement of clear supernatant liquor, providing no other disturbing factors are present. Under no consideration, however, should sludge be accumulated in the digester to within less than 1 ft. below the overflow pipe; otherwise, an excessive amount of finely divided solids such as are usually present at the sludge liquor junction will be buoyed up by gas evolution and carried over in the overflow. It is customary to take off the overflow liquor at a point 12 to 18 in. below the liquid level, for protection against possible scum formation. This gives a longer detention period, and insures against short-circuiting of raw sludge through the tank and out the overflow.

Under proper operating conditions a normal digester overflow liquor should not contain more than 0.30% total solids, of which about two-thirds are dissolved and one-third suspended. The greater part of the suspended solids are readily settleable after being removed from the main body of the digester, as they consist largely of small granular solid particles held in suspension by violent gas evolution. The volume of overflow liquor is somewhat less than the amount of raw sludge introduced. Accurate measurements at Aurora, Illinois, during an extended test period showed a daily input of 880 cu. ft. of 94% raw sludge per day, while the overflow liquor amounted to 755 cu. ft. per day. This difference may be accounted for by the reduction in solids due to digestion. In a primary treatment plant handling an average

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domestic sewage, the volume of overflow liquor will be only 0.07 to 0.15% of the total sewage flow. This small flow with its low solid content can have no detrimental effect on the subsequent treatment process when returned to the raw sewage, especially if it is well distributed over the entire day.

Factors that disturb the supernatant liquor are high and low temperatures, violent stirring, and the introduction of too thin a raw sludge, or too large a volume of raw sludge at one time into the digester. Observations at numerous unheated digestion plants show that invariably after the winter months when digestion is accelerated, scum production increases and the supernatant liquor becomes heavily charged with solids. This condition would be entirely eliminated if an even digester temperature were maintained all year round.

Considerable interest in thermophilic digestion has been evinced during the past year. Our experience based on large-scale tests, carried out at Aurora, Illinois, showed that these high temperatures (130° F.) produced a highly putrescible overflow that would require special treatment before it could be returned to the raw sewage. Average results showed that this material contained 1500 p.p.m. suspended solids, 450 p.p.m. of which were non-settleable.

Comparative tests have shown that violent agitation in a digester causes scum formation and increases the solid content of the supernatant liquor, while gentle stirring eliminates scum and has no effect on the suspended solid content of the overflow.

Observations at numerous plants show that the pumping of too large a volume of sludge at one time increases the putrescibility of the overflow, and tends to set up a condition in the digester somewhat similar to the effect of violent agitation, where the sharp line between sludge and supernatant liquor is destroyed, and the latter becomes a thin sludge of 1% to 2% solids. This condition is often met where waste activated sludge is pumped directly into the digester instead of being first concentrated, such as by returning it to the primary settling tank.

In order to utilize the effective digestion capacity, that is, the capacity below the clarification zone, to best advantage, it is necessary to digest the raw sludge as quickly as possible, and to secure the maximum average sludge density.

Sludge Heating—It is now generally recognized that sludge heating is highly beneficial, even in the more temperate climates. Recent plant studies show that the rate of digestion increases with temperature up to about 100° F., after which there is a lag, until the thermophilic range is reached. A number of plants now hold a temperature of 90° to 95° F. instead of 75° F. to 80° F., which was formerly thought to be the optimum.

Large-scale tests on digestion at 130° F. as compared with 90° F digestion have failed to show a more rapid rate of digestion, or greater gas production at the higher temperature. On the other hand, 130° F digestion gave unfavorable results in that it caused scum formation increased the hydrogen sulphide content of the gas, and produced a digested sludge that was difficult to dewater.

Addition of lime for pH value adjustment now has a recognized place for correcting sludge acidity, especially where a tank is being put into operation. After digestion is once established in a heated tank, however, lime additions are rarely required because of the alkaline nature, and buffer action of the seeding sludge. Where certain organic wastes, such as from creameries and canneries, enter a plant, a frequent check on the pH value of the sludge is advisable, as these materials tend to form organic acids which inhibit gas production and cause liquefaction. As a rule, when digestion is well established the pH value of the sludge varies from 6.8 to 8.0.

Stirring, whether slow or rapid, aids digestion because of its action in intimately mixing the raw and digested sludge. Rapid stirring, however, has the disadvantage in that it causes the sludge to bulk and so reduces the effective depth of the digester. Records show that stirring increases the gas production from 10 to 30%. It has been argued that this increase is due almost entirely to carbon dioxide. Tests have shown that this is not the case after digestion is well established. Gas analyses at a number of plants show a carbon dioxide content of 25 to 30%, depending on the nature of the sludge.

Seeding—The question of amount of ripe sludge required for seeding has become of greater importance in view of the recent studies on the use of sludge storage tanks, stage digestion and continuous sludge dewatering methods. Formerly a 40:1 ratio (40 lb. of ripe sludge volatile solids for each pound of raw sludge volatile solids added daily) was considered necessary at 70° F. This was later reduced to 20:1, when temperature and pH value control was employed. The latter is the equivalent of a 30 to 35-day digestion period. At Aurora it was demonstrated that a satisfactory digested sludge could be obtained continually in 12 days at 90° F. A constant ratio of eight parts ripe to one part raw volatile solids was maintained during this test.

Concentration of raw sludge ahead of digestion is now being given considerable attention with the idea of cutting down heat losses, reducing the volume of overflow liquor, and increasing the average sludge density in the digester. Laboratory tests have shown that concentration of the raw sludge to 18% solids has very little effect on the digestion rate. Indications are that this high concentration may be obtained by the use of auxiliary thickeners, or decanting tanks, especially in the colder climates where the sludge will not become septic within 2 or 3 days.

Sludge storage capacity to take care of 5 to 6 months' accumulation of digested sludge is now being provided for at some of the larger plants in separate, unheated tanks. The system in operation at Grand Rapids is typical of the type of installation. It has the advantage in that digested sludge is withdrawn at the same time that raw sludge is introduced. This system may reduce the volume of overflow liquor to less than 35% of the volume of raw sludge pumped each day.

Conclusion—Developments indicate that continuous disposal methods such as by means of vacuum filters, should in many cases eventually eliminate sludge storage space and drying beds. This, together with

temperature control at 90° F., raw sludge concentration to about 15% solids, gentle stirring, and pH value adjustment to about 7.0 when required, should give satisfactory digestion with an effective capacity of less than 5.0 cu. ft. per lb. of volatile solids added per day. For an average domestic sewage containing 200 p.p.m. suspended solids, this is equivalent to 0.56 cu. ft. per capita for a complete treatment plant removing 90% of the suspended solids.

'SLIPSEAL' PRECAST ASPHALTIC SEWER JOINT

By E. FRENCH CHASE†

The development of a permanent, tight, and slightly flexible sewer-pipe joint that can be used under any and all conditions and that will save in construction and maintenance costs, is of major importance in the design and construction of sewerage systems. Considering the different methods and materials now being used and the infiltration and leakage tests required, it is evident that engineers are beginning to regard tight sewer joints as very essential. Infiltration of ground water decreases the carrying capacity of the sewer system and in-

Swabbing 'Slipseal' Joint with Solvent Before Laying Pipe

creases the pumping and sewage treatment costs. Leakage contaminates the underground water supplies and may cause epidemics. Also, leaky joints permit roots to enter and block the sewers.

In attempting to solve this problem we collaborated with Gladding, McBean & Co., manufacturers of vitrified clay pipe. A precast asphaltic joint, molded into the bell end and onto the spigot end of each pipe, was finally developed under the supervision of J. C. Johnston, northern division sales manager for the company, assisted by W. E. Lemly and Howard Mauser of the same firm, and by H. E. Faulkner, engineer of tests for the city of Seattle, and myself.

This joint, which has been given the trade name of 'Slipseal,' is similar in type to the Stanford joint developed in England in 1873, but is an improvement in several respects.

The material in the Slipseal joints at present used in Seattle is a mastic compound composed of 60% inert matter, obtained by grinding clay pipe fragments to a fineness that will pass a 100-mesh Tyler

*Reprinted from "Western Construction News," September 10th, 1931, issue, p. 481.

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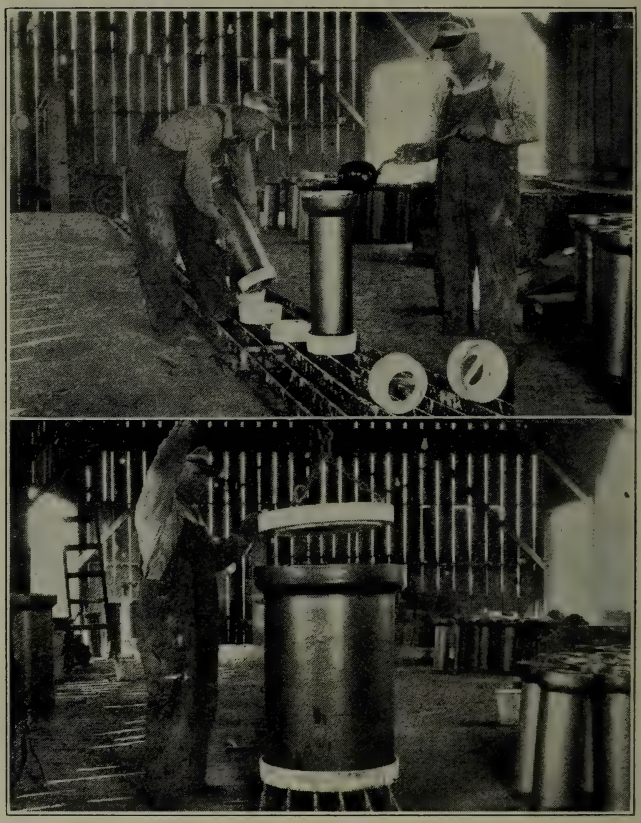


(Upper) Pouring 'Slipseal' Precast Asphaltic Joints at Sewer Pipe Factory. Male and Female Molds in Foreground. (Lower) Setting Mold in Bell End of 21-in. Pipe.

screen, and 40% 'Petrolastic' or its equal. This compound is flexible at freezing temperature; softens at 200 deg. F.; flows at 300 deg. F.; and has a penetration of 7 to 8 at 77 deg. F. The compound is mixed and cast at 400 deg. F.

Machine-made steel forms are used for precasting the joints, which are tapered (1:20) and designed to make a tight fit when the spigot end of the pipe is pushed into the bell in laying the sewer. The scarified bell and spigot ends of the sewer pipe are first thoroughly cleaned and dried, and then painted with a solvent ('Oronite' or equal) about one hour before the joints are poured to secure proper adhesion. The tapered molds are first whitewashed to prevent adherence of the hot compound and to provide a coating on the exterior of the joints for ease in handling. After pouring, the molds are not removed until the compound has cooled. The pipe with precast joints attached are easily handled in shipping, without injury.

About 30 minutes before lowering the pipe into the trench, the joints are swabbed with a priming solution ('Oronite' or equal) and again swabbed just before jointing together. A saddle or hand jack gives sufficient leverage to 'drive home' pipe 18-in. diam. or over, and a bar is sufficient for the smaller diameter pipe.

Within an hour after laying, the joint becomes a homogeneous mass. We have broken a number of joints which were made under water and found them perfect. We have also made perfect joints with pipe subjected to freezing temperature for 48 hours prior to laying, and again subjected to freezing for 24 hours. Tests have shown no leakage up to 70-lb. pressure, the breaking point of the pipe.

There are many advantages in favor of Slipseal joints over cement-mortar joints or asphaltic compound joints poured in the trench:

1. It is more economical to precast these joints at the plant where the pipe is manufactured, and a much better joint is secured.
2. A sewer line can be laid faster with these precast joints.
3. A narrower trench or tunnel can be used, bell-holes being unnecessary.
4. As the joints are made as fast as the pipe is laid, the ditch can be immediately backfilled. Less bracing and lagging is therefore required.
5. As the joints can be made with the pipe partly under water, less pumping is required.
6. The Slipseal joints being accurately centered, a perfect flow-line is secured.
7. As the joint is flexible, slight settlement can occur without injury to joint or pipe.

This joint is being used by the city of Seattle in a major sewer project known as the 'Lake Washington Intercepting Sewer System' to cost, when completed, $5,000,000. One unit, recently completed, consisted of 5 miles of 8 to 24-in. triple-strength vitrified clay pipe. A second unit included 1 mile of 8 to 21-in. pipe. There are two pumping plants in the first unit, three in the second, and there will be sixteen in all; the electric power for which will cost $3000 per month. Tight joints, therefore, are essential.

REFINED SEWAGE TREATMENT IS JUSTIFIED*

By CARL WILSON†

Two years ago H. A. Van Norman, chief engineer and general manager of the Los Angeles Department of Water & Power, believing that reclamation of water from sewage must sooner or later be undertaken in southern California, authorized the construction in Griffith Park of an experimental plant which should enable studies of the many problems involved to be carried on over a sufficient period to render them conclusive. The plant built was designed and operated under the direction of R. F. Goudey, sanitary engineer of the Department of Water & Power.

This plant has now been in continuous operation for nearly 18 months and it has demonstrated the reasonableness of reclamation. Utilizing the most modern ideas in activated sludge plants with separate sludge digestion and chlorination of the effluent, followed by the most complete water treatment processes, including super-chlorination and activated carbon filtration, the plant has continuously produced as final effluent a perfect table water, safe and in every way acceptable for human consumption. The records of the plant show that apparently all kinds of organic wastes, both domestic and industrial, can be successfully treated by the activated sludge process, and at costs so low that it actually becomes expensive not to subject sewage to complete treatment even where water scarcity does not exist, and where the final effluent is to be wasted into streams or the ocean.

Recent inspection of over 25 typical high-grade sewage disposal plants in eastern cities revealed the fact that their cost of producing a markedly inferior effluent was, in most cases, $25 or more per m.g., and this cost is incurred for disposal only. At Los Angeles, where sewage disposal has given way to sewage utilization, it has been demonstrated that a superior activated sludge effluent, of guaranteed safety and suitability for irrigation and some other uses, can be continuously produced from combined domestic and industrial sewage at not to exceed $15 per m.g. For an additional cost of $10 to $12 per m.g., this effluent can be converted into a clear and sparkling water suitable for the highest uses. The figures given cover all operating costs, but do not include interest on capital investment.

It will probably be admitted that, in a semi-arid region, such a demonstration means that reclamation will soon become an accomplished fact. To men of imagination, the Los Angeles results mean much more than this. Even where water is so abundant that its reuse may never be necessary, it now appears economically desirable to adopt these refined methods of treatment instead of discharging partially-treated effluents into streams to destroy fish, create nuisances, and overload water treatment plants farther downstream. Many eastern and southern cities use surface waters so heavily polluted with raw or improperly treated sewage that their water treatment plants

*Reprinted from "Western Construction News," October 25th, 1931, issue, p. 559.
†Director of Sanitation, Los Angeles Department of Water & Power.

are overloaded and working with little or no reserve margin of safety. Fresh-water fish, normally a source of considerable wealth and recreational value, have been driven from sewage-laden streams, while many rivers are no longer safe for bathing or inviting for boating.

Refined treatment of sewage, along such lines as have been demonstrated by the Los Angeles experiments, would restore these streams to their originally pure state, when they could be restocked with fish. Moreover, such a procedure would undoubtedly reduce the present prevalence of typhoid fever, for typhoid has now become largely a "vacation disease" contracted through drinking or bathing in sewage-polluted waters. City and town water supplies are generally well protected, but our open streams, from which the traveler and camper must often drink, are grossly polluted without thought of the consequences. When sewage can be made safe and inoffensive at such reasonable cost, it seems apparent that not to do so is criminal.

England has permitted the lower Thames river to become so heavily contaminated with sewage that she recently launched a campaign to clean up the situation, so that salmon may again ascend the river to spawn. The cost of this work will aggregate millions of dollars, but it is considered a wise expenditure. Americans charged with the responsibility for sewage disposal who think high-grade treatment of sewage is wasteful would do well to ponder upon Alexander Houston's remark anent the expected restoration of the Thames to such a condition of purity. He says (25th Annual Report, for 1930, p. 9), "* * * such an event would be of immense sentimental value in relation to the faith of water consumers in the safety of the river Thames as the main source of water supply to London, and a stimulus to those concerned with its purification."

The need in California for superior treatment of sewage is evidenced in San Francisco bay, San Diego bay, and along the west-coast bathing beaches at Los Angeles, as well as at Santa Barbara. In each of these locations, pollution is so severe that heavy expense must be incurred to correct the damage. The only prevention of such a deplorable situation is to be found in high-grade sewage treatment, either with or without reclamation of water for useful application.

If the Los Angeles plant can point the way to such a goal, it has not only justified its construction, even though reclamation should never be realized, but should bring renown to Van Norman, who conceived and instigated the experiments for his contribution to human welfare.

The experiments are not yet completed, and many problems remain to be solved. A survey of the recent literature of sewage treatment reveals how much investigators are at variance in their opinions. One writer considers sewage reduction simply a series of chemical processes, and he talks of dissolved oxygen, free carbon-dioxide and pH as the only factors involved, while the next writer regards the treatment process as purely a biological one. In reality, it is both chemical and biological, and in the effort to determine just what part is played by each of the many factors which enter into the process, the Los Angeles plant is collecting and attempting to correlate a wider range of data than ever before assembled. The studies undertaken are chemical, bac-

teriological, microscopical and physical. New methods have had to be devised, and some most interesting lines of investigation have already been disclosed. Among these is an intensive study of the dominant types of bacteria which appear in the sludge, as well as the floral differences between return sludge and reaerated activated sludge. Significant changes in the flora and fauna of "bulked" sludge are receiving much attention, and it is hoped this troublesome phenomenon will be largely explained.

Aeration studies are directed toward reduction of added air, as this is the most expensive item in present practice. By refinement of methods, the power expended in aeration has been reduced from 40 hp. per m.g., as commonly used, to 15 hp. per m.g. at the Los Angeles plant. Apparently, by scientific methods of control it will soon be possible to further reduce the latter figure.

One fact has been clearly demonstrated at the experimental plant, and that is the imperative necessity of constantly controlling all features of plant operation by laboratory results. The laboratory becomes the one most important part of a plant, for only through complete knowledge of the ever-changing conditions in each plant unit is it possible to produce the best effluent at the lowest cost. Is more or less air required, and if so, how much? Is the pH rising or falling? Are "bulking" conditions imminent? Only the laboratory can answer these questions, but successful and economic operation depends upon accurate answers in the shortest possible time.

Success, therefore, demands daily laboratory service, with the laboratory findings intelligently interpreted and diligently applied. The technicians must be highly-trained specialists in the biology and chemistry of sewage treatment. The Los Angeles experiments have proved this beyond peradventure.

SEWERAGE IMPROVEMENTS, PHOENIX, ARIZONA*

Modern Activated Sludge Treatment Plant; New Outfall and Trunk-Line Sewers; and Extensions to Collecting System; at Cost of $900,000

By W. J. JAMIESON† and CLYDE C. KENNEDY‡

The city of Phoenix, Arizona, has at present, a construction program under way involving new outfall and trunk sewers, extensions to the collecting system, and a sewage treatment plant of the activated sludge type, representing an expenditure of $900,000. Construction of the Roosevelt dam, and more recently, the Coolidge dam, has brought about a rapid development in large agricultural areas along the Gila and Salt rivers. Phoenix is centrally located with reference to these newly developed agricultural areas and has, in consequence, enjoyed a phenomenal growth during the past 20 years. In addition to being the capital, it is the wholesale and distributing center of the state. Because of its delightful winter climate, with practically continuous sunshine, it has achieved great popularity as a winter resort, with many beautiful homes, not only in Phoenix itself, but in the foothill section to the north and east of the city. This rapid growth has made it necessary to meet the requirements of the increased population by the provision of a larger water supply, which has just been completed at a cost of $2,342,000, and the increased sewerage facilities now under construction.

The present sewer system dates from 1910, when the population was little more than 10,000. Additions and extensions were made from time to time until the city expanded in area to the point where, owing to the lack of gradient, it became impossible to obtain proper depth for further extensions. In addition to the present population of 45,000 within the corporate limits, a considerable population, estimated at 20,000, has grown up outside the city boundaries, which could not be annexed because of the inability to provide sufficient water and adequate sewerage.

The existing sewage disposal plant is a double unit, Cameron-type septic tank designed for a flow less than one-fifth of that now present, with no provision for sludge removal, and no other treatment than the negligible clarification secured in the tank. This tank, apparently poorly built, has caused considerable difficulty, due to the failure of the various sections of the roof slab. The sewage, passing through the tank, carries out a large portion of partly digested septic sludge in the effluent and becomes saturated with the gases from the digesting solids. This effluent, flowing through an open channel in the bottom land along the Salt river, has, during the summer months,

*Reprinted from "Western Construction News," September 10th, 1931,issue, p. 461.
†City Engineer, Phoenix, Arizona.
‡Consulting Sanitary Engineer, San Francisco.

Model of Phoenix Sewage Treatment Plant Made by D. E. Reinoehl, Architectural Engineer with Clyde C. Kennedy

produced a zone of acute odor nuisance 2 miles wide and 5 miles long.

As an outcome of these conditions, a bond issue for $817,000 was authorized June 23, 1930. This amount, added to a previous unspent bond issue of $78,000, has provided the fund for the present program of construction. Studies on the quantity of flow and characteristics of the sewage, on the basis of which the design of lines and plant was made, were undertaken in August, 1930, and continued for one month.

On the basis of a preliminary report, which had been made prior to calling the bond election, the amount set up in the bond issue provided for construction of a primary-treatment unit only. After thorough study of the situation, it became obvious that the construction of a plant which provided for primary treatment only would not satisfactorily meet the conditions. Inasmuch as the effluent from such a plant would be discharged into the channel of the Salt river, which during practically the entire year carries no flow, a primary treatment plant would not prevent the condition of acute nuisance, which now exists, from continuing in the future. It was determined to make every possible effort to provide complete treatment at the present time, with a shorter period of future adequacy, so that a stabilized and potentially valuable effluent could be produced instead of a nuisance-creating one. To that end the plans for the work, under construction, were developed.

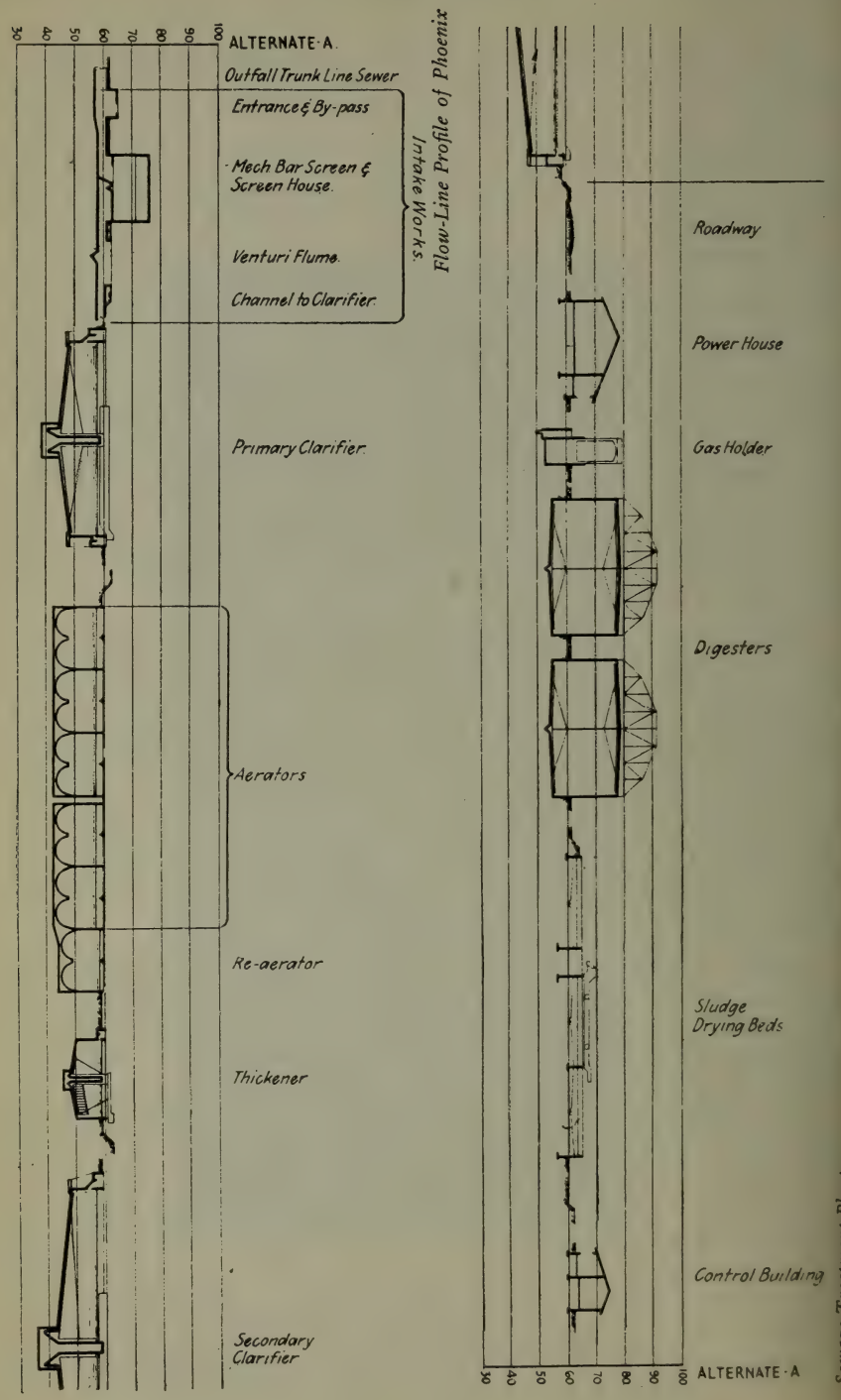
During the period that studies on the sewage were carried out, the rate of flow varied between 5 and 11.4 m. g. d., averaging 7.3 m.g.d. The suspended solids varied from 75 to 275 p.p.m., while the bio-chemical oxygen demand varied between 90 and 650 p.p.m. As might be anticipated, the low content of suspended solids and the low B.O.D. came at the period of minimum flow and the high content of suspended solids and high B.O.D. at the time of peak flow. The sewage at the time of low flow in large measure represented the discharge of cooling water and leaks from fixtures. The sewage of Phoenix is domestic in character, with a small amount of industrial wastes, principally from creameries and laundries. There are no packing house wastes discharging into the city sewers.

Sewage Treatment Plant—The plant, as designed, consists of a bar screen, 5 by 5 ft. with 1-in. clear openings, equipped with Dorrco-type bar-screen cleaning mechanism, with screenings hopper, and overhead track and conveyor to transport the hopper to a truck-loading door in the building housing the bar screen.

In the pipe-line following the bar screen is the Venturi flume, with register operated by remote control on the power-house switchboard. This will record the rate of flow and total flow.

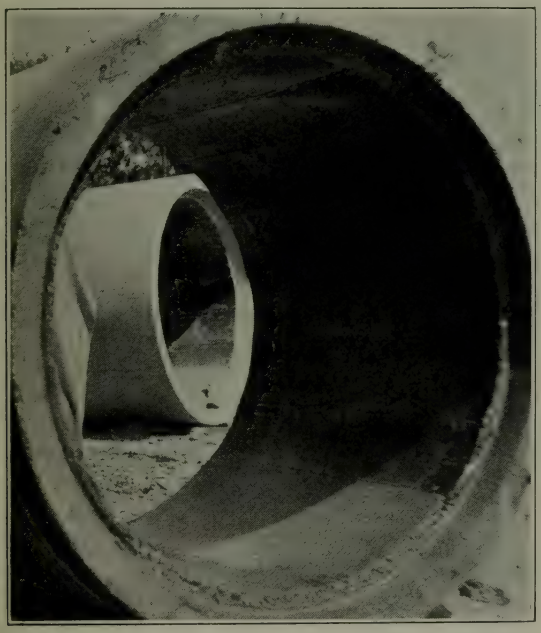
Connected to the Venturi flume by a closed conduit is the primary clarifier, 80 ft. square, with a side-water depth of 10 ft., which will give a nominal detention period of 1 hr. 6 min., with an overflow rate of 1660 gal. per sq. ft., per 24 hr. for the designed flow rate of 12 m.g.d. This clarifier is to be equipped with a Dorrco traction-type mechanism for removing the sludge and skimming the surface.

From the clarifier the sewage goes to the aeration unit, which consists of five primary aeration tanks and one reaeration tank, each 25.5


Flow-Line Profile of Phoenix Sewage Treatment Plant
ALTERNATE-A.
Outfall Trunk Line Sewer
Intake Works
Entrance & By-pass
Mech. Bar Screen & Screen House.
Venturi Flume.
Channel to Clarifier.
Primary Clarifier.
Aerators
Re-aerator
Thickener
Secondary Clarifier
Roadway
Power House
Gas Holder
Digesters
Sludge Drying Beds
Control Building
ALTERNATE-A
30 40 50 60 70 80 90 100

ft. wide by 330 ft. long, with a maximum water depth of 14 ft. In each unit are two Imhoff-Dorrco paddles extending the full length of the tank, each of which is operated through chain drive and gear reduction by a 10-hp. motor.

The air is delivered through a single row of filtros plates, placed on a ledge on the center-line of the tank 4 ft. above the bottom. The air piping provides for supplying the plates in sets of 10, two sets to be fed from the same air line and each line provided with an orifice plate and manometer connections for the determination of air delivery.



Reinforced Concrete Pipe, 54-in. diam., with Vitrified Clay Liner Blocks, Phoenix Outfall Sewer

The primary aeration tanks have capacity sufficient to provide for a 6-hr. aeration period for a sewage flow of 12 m.g.d., with allowance for 25% returned sludge.

The reaeration unit is identical in dimensions with the primary ones, except that provision is made for maintaining the liquid level 12 to 18 in. above that of the primary aeration tank. Reaerated return-sludge is carried in a conduit directly above the channel for the primary-clarifier effluent. The two streams are fed into the aeration tank at the same point in order to insure rapid, thorough mixing.

The secondary clarifier, into which the aerated sewage passes, is 140 ft. square, with side-water depth of 9 ft., nominal detention period 2 hr. 42 min., and an overflow rate of 600 sq. ft. per 24 hr., with a sewage flow rate of 12 m.g.d. The sludge from the secondary clarifier returns by gravity through a pipe to the end of the aeration unit,

from which it is lifted by air into the reaeration tank or carried through a closed pipe-line to the influent end of the aeration tanks, with branch lines through which excess sludge may be discharged to the thickener or the primary clarifier. A centrifugal pump of 3500 g.p.m. capacity is provided in the secondary-sludge pump-house, which may be used to drain either the secondary clarifier or any of the aeration tanks in case of emergency. The piping arrangement permits this pump to be used as an auxiliary to, or as a substitute for, the air-lift pump. The secondary clarifier is likewise equipped with a Dorrco traction-type mechanism for collecting sludge.

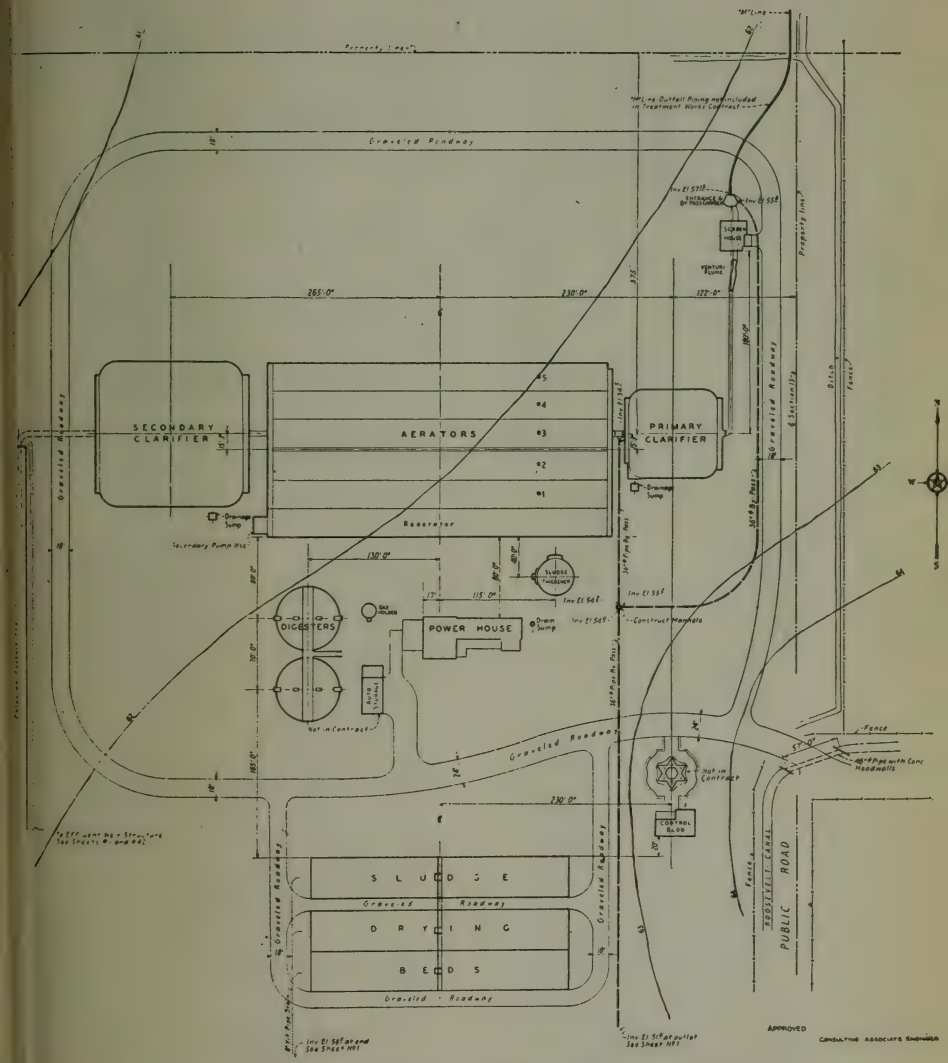
From the secondary clarifier, the sewage flows into the chlorination dosage channel, which is a ditch with gunited bottom and banks 5 ft. wide at the bottom and 17 ft. at the top, water depth 4 ft. This channel is 800 ft. long and provides a detention period of 15 min. for a sewage flow rate of 12 m.g.d. At the outlet end of this contact chamber, provision is made for connection to one of the main canals of the Roosevelt irrigation district, by which, it is hoped, use can be made of the entire plant effluent. However, there is also provided a pipe-line beneath the canal for conveying the effluent onto a tract of land in excess of 600 acres, which the city owns along Salt river, where it may be used for irrigation.

Sludge from the primary clarifier will be pumped into a sludge-thickening tank 35 ft. diam. with 9-ft. side-water depth, equipped with a Dorrco traction-type mixing and thickening mechanism, into which will also be discharged the excess activated sludge, where the two will be thoroughly mixed. The detention period for the mixed liquors will be 1 hr. 45 min. This practice, will, it is believed, greatly reduce the amount of sludge to be pumped to the digestion tanks and, in large measure, solve the problem of disposal of digestion tank effluent.

From the sludge thickener, sludge will be pumped to two 60-ft. diam. sludge digestion tanks, each 23 ft. deep, provided with Dorrco truss-type thickening mechanisms. The tanks will have concrete slab covers, with domes for gas collection, and will be heated by means of hot-water coils placed on the inside walls. On account of the high average annual temperature, it was not felt necessary to cover the tanks with earth, as in colder communities.

The sludge drying beds are six in number, each 40 by 125 ft., provided with concrete side walls. These beds are equipped with a truss supported belt-conveyor mechanism, running on wheels on light rails on the side walls, for conveying sludge to the sides and discharging it into trucks, which can be operated in a depressed roadway adjacent to the beds. Power for the conveyor is furnished by electric motor, with a reel cable attached to a plug in the end of the beds.

The power-house consists of a pump room, compressor room, switchboard room, boiler room, chlorination room, and operators' room, together with dressing rooms, lockers, showers, and toilet. In the pump room are the sludge pumps, three in number, Dorrco-Barnes plunger type, each of 100 g.p.m. capacity. In the compressor room are the air compressors, four in number, General Electric centrifugal, connected through gearing to General Electric motors, each



Phoenix Activated Sludge Plant

with a capacity of 1000 c.f.m. of free air. The operating speed of the blowers is 16,500 r.p.m. Air to the blowers will be fed through air filters to eliminate dust particles and prevent clogging of the aerator plates.

In the switchboard room will be all electrical control mechanisms. Operating levers and buttons will be installed on a blind front switchboard, while the switches will be placed on the wall behind the board. In the boiler room will be placed a Bryant gas steam-boiler for heating water for circulating through the digestion tanks, also for heating the building itself and providing hot water for showers and wash basins in the operators' locker room; together with gas meters, thermometer, manometer, and water circulating pump. In the chlorination room will be installed all of the equipment for chlorination of the treated effluent, together with hoist and storage space for handling chlorine in carload shipments in ton containers. The control building, which is situated near the main plant entrance, contains the office of the superintendent and the laboratory, in which provision is made for running all of the tests necessary for operating the plant.

Contract for the plant was awarded to the Phoenix-Tempe Stone Co., of Phoenix. At the present time (August 29) excavation for the primary clarifier has been completed and 80% of the excavation for the aeration tanks. Foundations for the power-house and control building have been placed and concrete is being poured in the primary clarifier. The bid price for the completed plant, including the effluent line from the plant, was $494,000.

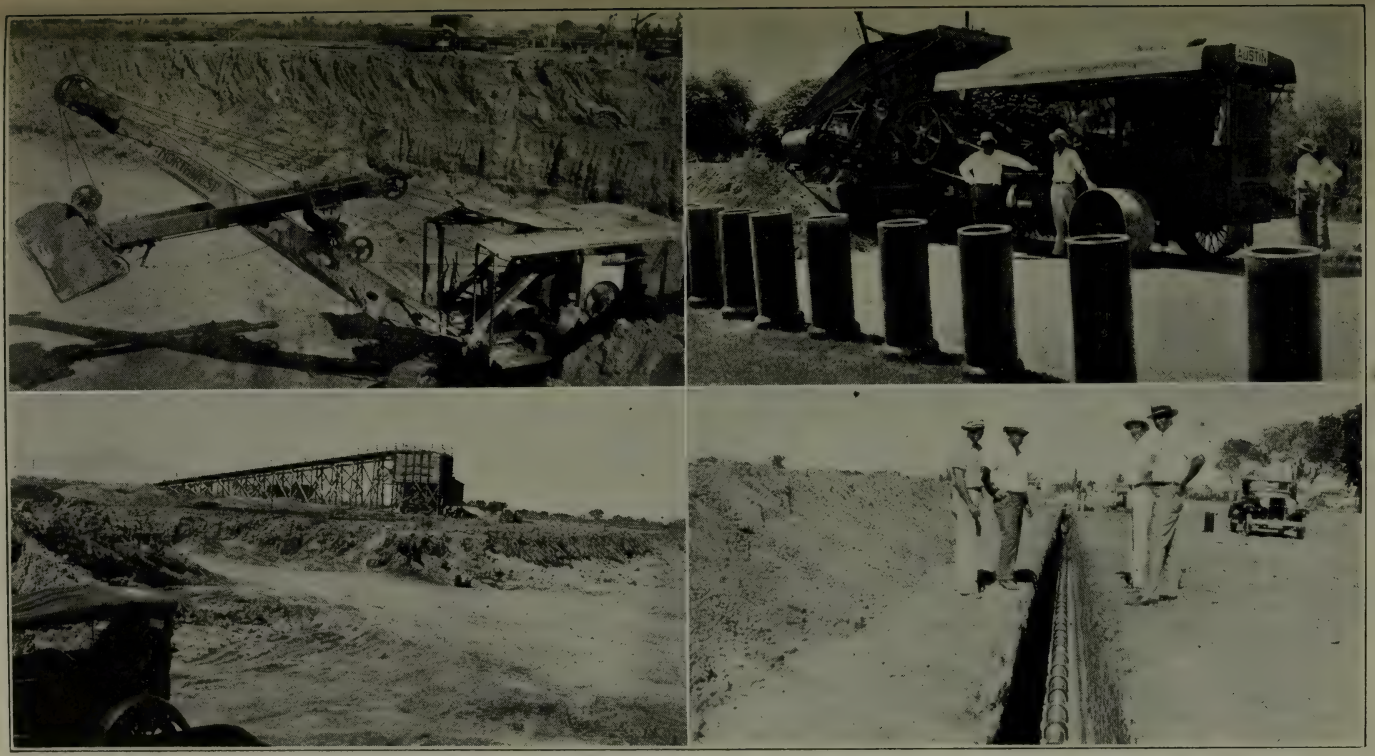
The trunk-line outfall sewers consist of 10 miles of pipe-line from 54 in. to 12 in. diam. The 54-in. pipe-line is reinforced concrete, lined on the upper 270° of its circumference with vitrified clay liner-blocks with the edges ground to make close contact joints. The sewers from 48 in. to 24 in. are centrifugally-cast reinforced concrete pipe and the 21-in. to 12-in. pipe is of standard vitrified clay.

Lengths of the various sizes of pipe are as follows:

Diam.	Lin. ft.	Diam.	Lin. ft.
54	1300	27	6700
48	2700	24	6800
42	5300	21	3600
39	2400	18	800
36	5100	15	3100
33	4000	12	2800
30	8700		

The concrete pipe is being manufactured by the American Concrete & Steel Pipe Co. and the United Concrete Pipe Corp., of Los Angeles, both having plants in Phoenix; and is being tested to meet the requirements of the specifications of the American Society for Testing Materials. The pipe produced has proven to be of excellent quality as shown by loading tests. The vitrified clay pipe is being supplied by the Pacific Clay Products Co. and Gladding, McBean & Co., from plants near Los Angeles, and the vitrified liner blocks are being furnished by Gladding, McBean & Co. All the vitrified clay pipe has been tested to A.S.T.M. standards.

The contract for pipe-laying was awarded to Gogo & Rados, of Los Angeles, at a bid price of $330,000. While some bad ground has



(Upper Left) Power Shovel Excavating for Phoenix Sewage Treatment Plant, Phoenix-Tempe Stone Co., Contractor. (Lower Left) Concrete Aggregates Plant at Edge of Excavation for Sewage Treatment Plant. (Upper Right) Gogo, of Gogo & Rados, Contractors on Main Sewers, and F. Bromley, Assistant Engineer in Front of Trencher on Roosevelt st., 21-in. Vitrified Clay Pipe-Line. (Lower Right) 8-in. Vitrified Clay Pipe Sewer in Northwest Section of Phoenix; Left to Right—Unknown; Spencer, Inspector; F. Bromley, Assistant Engineer; Burn of Hayner & Burn, Contractors

been encountered, the average laying progress has been good. More than 40% of the pipe has been laid to date.

The extensions to the collecting system, consisting of 40,000 lin. ft. of 8-in. and a few hundred feet of 6-in. pipe, are of vitrified clay. G-K joint compound has been used in all the joints. Progress on this contract has been very satisfactory and the work is more than 75% complete. The contract for this portion of the work was awarded to Hayner & Burn, of Las Cruces, New Mexico, on a bid of $32,000.

General supervision of the work is by W. J. Jamieson, city engineer of Phoenix, with B. E. Gilpin, deputy city engineer, in direct charge. Clyde C. Kennedy is consulting associate engineer, and R. E. Campbell, resident engineer, represents the consulting engineer.

SALINAS SEWAGE TREATMENT PLANT*

Results of First Year's Operation of a California Plant Combining Sludge Digestion with the Activated Sludge Process for Treatment of a Strong, Greasy Domestic Sewage

By T. R. HASELTINE†

On May 27, 1930, the city of Salinas, California, placed in operation a sewage treatment plant which combines separate sludge digestion with the activated sludge process. This plant and other sewerage improvements were described in "Western Construction News" September 25, 1930, issue. The following article will give the results of the first year's operation and will enumerate the troubles encountered and the means used to overcome them.

Character of Sewage—Salinas has an average population of 10,000 and an average daily sewage flow of 620,000 gal. Monthly average flows are 16% higher during the summer and 17% lower during the winter, due in part to seasonal variations in the contributing population, and also to lowered ground water levels during the winter.

The sewage is almost entirely of domestic origin, but in spite of this fact it is extremely strong and difficult to treat, the grease content being particularly high. It is this extraordinary strength that has caused all of the troubles encountered during the year, aside from minor difficulties to be expected in putting a new plant into operation. A typical analysis of the crude sewage is given in Table I.

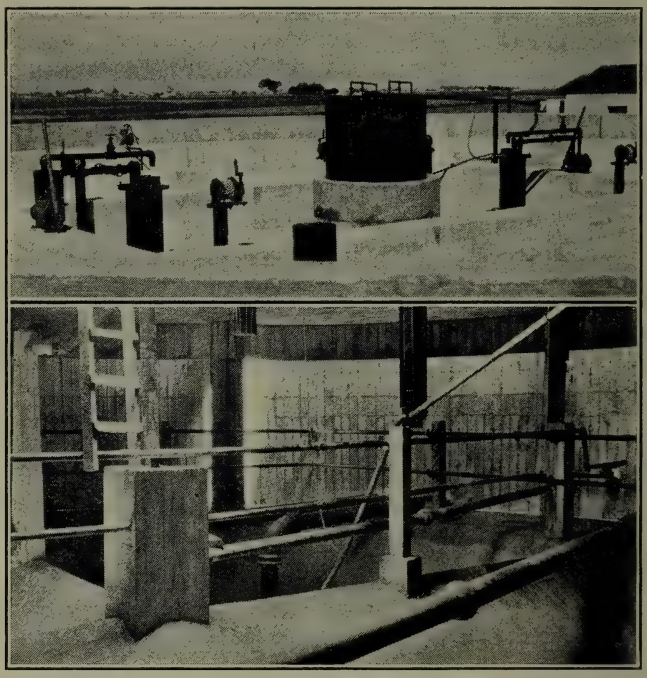
TABLE I

	Average of 11 analyses of daily composite samples collected throughout the year 1930-31 (made by California State Department of Health)
Residue on evaporation	1364 p.p.m.
Loss on ignition of residue	651 p.p.m.
Total suspended matter	361 p.p.m.
Volatile suspended matter	304 p.p.m.
Settleable solids	26 cc/liter
Oxygen consumed	218 p.p.m.
Five-day B.O.D.	489 p.p.m.
Organic nitrogen	23 p.p.m.
Ammonia nitrogen	42 p.p.m.
Nitrate nitrogen	0.5 p.p.m.
Ether soluble	202 p.p.m.
Insoluble soaps	138 p.p.m.
Total grease	304 p.p.m.
pH	7.2

The sewage, practically all of which flows by gravity, reaches the plant in a slightly septic condition, the hydrogen sulphide content ranging from 0 to 2 p.p.m. Upon reaching the plant, this sewage passes through a bar screen having ¾-in. clear openings and into the wet well of a pumping station. From there it is pumped to the primary settler by one or more of three float-operated 6-in. Fairbanks-Morse horizontal sewage pumps.

*Reprinted from "Western Construction News," September 10th, 1931, issue, p. 467.
†Chief Operator, Salinas Sewage Treatment Plant.

Preliminary Clarification—The primary settler, which is equipped with a Dorr traction-type mechanism for skimming and sludge removal, has an average theoretical detention period of 1.4 hours, and an average settling rate of 900 gal. per sq. ft. per day at present flow. Sludge is drawn by gravity to a sump, from which it is lifted to the digester by a Barnes piston pump.



Digester at Salinas Sewage Treatment Plant, Showing Floating Concrete Roof (Upper), and Interior (Lower)

Due to the high grease content of the crude sewage, a heavy gray scum forms on the surface of the tank, and it is necessary to operate the skimming mechanism almost continuously, thereby removing a large amount of water along with the grease scum. As originally designed, this material flowed to the sludge sump, from which it was pumped to the digester—it being necessary to pump as much as 5000 g.p.d. In February, 1931, a scum concentration tank was built to receive all of the discharge from the skimming mechanism. When full, this tank is skimmed by hand, the concentrated skimmings going to the sludge sump, as before, while the remaining water is drawn off through a valve in the bottom of the tank and returned to the wet well of the pump station. By this method the volume of liquid, including scum, pumped to the digester has been reduced fully 95%.

The primary settler removes 52% of the suspended matter, 27% of the B.O.D., 13% of the organic-plus-ammonia nitrogen, and 27% of the total grease. Prior to March, 1931, excess activated sludge—which averages 0.6% solids—was pumped directly to the digester.

Since then, it has been discharged to the crude sewage, an average of 14,500 g.p.d. being disposed of in this manner whenever the sludge is wasted. As a result of this practice, the total volume of sludge pumped to the digester has been reduced 30 to 70%, although the moisture content of the sludge removed from the primary settler has been increased from 94% to 96 or 97%. The scum formation on the settler has been reduced, and the percentage removal of suspended solids in the settler has been increased. Table II shows the performance of the settler and the effect of the addition of excess activated sludge upon sedimentation.

TABLE II

	Monthly Averages of				
	Days settler rec.act. sludge (%)	Daily flow (gal.)	Susp. solids in settler influent (p.p.m.)	Susp. solids in settler effluent (p.p.m.)	Removal of susp. solids (%)
June, 1930	0.0	578,000	264	148	44.1
July	0.0	620,000	398	183	54.2
August	0.0	620,000	282	159	43.9
September	0.0	.....	330	188	43.3
October	0.0	.....	395	192	51.6
November	0.0	.....	351	196	44.3
December	0.0	.....	435	212	51.4
January, 1931	0.0	.....	451	213	53.0
February	0.0	.....	416	225	44.1
March	63.3	521,000	580	239	59.0
April	90.0	624,000	492	211	57.1
May	58.6	645,000	472	193	59.1
June	89.5	582,000	509	167	67.5
July	73.3	719,000	450	204	54.7

Sludge Digestion—The digester is a circular tank with four square hoppers in the bottom. The roof, which rests on eight columns placed around the interior circumference of the tank, is a concrete slab, with a wall around its circumference that extends above and below the roof slab proper. This roof is entirely free from the supporting columns and, when the digester is full, it floats upon the sludge liquor. The maximum capacity of the digester is 34,100 cu. ft. or 3.41 cu. ft. per capita. Sludge enters the digester through a 4-in. riser pipe in the center of the tank and is withdrawn through four 8-in. pipes, one of which originates in each hopper. Sludge may be drawn from the hoppers to the sludge sump and pumped back into the digester, thereby circulating the tank contents from bottom to top. There is a gas collection dome in the center of the roof and all gas is metered and burned to control odors.

The method of starting the digester was described in some detail in the "California Sewage Works Journal," Vol. III. Although no seeding material or lime was used at the start, a pH of 7.0 was obtained in 80 days and a daily gas production of 8000 cu. ft. was developed 95 days after the digester was filled. During the first 7 months, very little activated sludge was digested; thus an excellent opportunity to observe the effect of the activated sludge on the digestion process was afforded.* The effects noticed were:

(a) 40 to 60% increase in gas production, due to digestion of activated sludge.

*The experiences with the digestion of activated sludge at Salinas are to be considered in detail in an article to be published in the October issue of the national "Sewage Works Journal."

(b) decrease in solid content of digesting sludge from 10%, when no activated sludge was being digested, to 5% when digester was receiving daily charges of activated sludge,

(c) decrease in volatile matter reduction from 55%, when no activated sludge was being digested, to 33% when digester was receiving daily charges of activated sludge.

The decrease in solid content of the digesting sludge reduces the digestion period, and this, coupled with increased daily charges of fresh solids resulting from the addition of excess activated sludge, is responsible for the decrease in volatile matter reduction. The practice of concentrating the excess activated sludge in the primary settler, which has been in use the last 5 months, has been successful in preventing a further decrease in the solid content of the digester, but as yet it does not seem possible to increase the solid content much above 5%.

The temperature of the digester, which is uncontrolled, has ranged from 61° F., during the winter, to 71° F., during the summer. The normal pH values without liming have been 6.8 to 7.0. The gas yield has averaged 5000 to 8000 cu. ft. per day during the winter, and 8000 to 13,000 during the summer, depending on whether or not activated sludge was being digested. The gas has an average heating value of 650 b.t.u. per cu. ft. Table III shows the results of four different digester gas analyses.

TABLE III

Date of collecting sample	Feb. 28	April 30	May 22	June 2
Cu. ft. of gas produced	6,856	14,224	8,032	13,070
Activated sludge digested previously	No	Yes	No	Yes
Average pH of digester	6.8	6.8	7.2	7.3
Average temperature of digester, °F.	62.0	66.0	68.0	68.0
Carbon dioxide, %	9.4	30.1	27.1	29.3
Methane, %	59.3	59.8	68.9	63.8
Nitrogen, %	4.4	4.1	4.0	4.4
Sulphur dioxide	None	Trace	None	None
Hydrogen sulphide, %	18.4	None	Trace	None
Air, %	8.5	6.0	7.0	2.5
Calculated b.t.u. per cu. ft.	723.	603.	624.	645.

The digestion of activated sludge seems to prevent formation of hydrogen sulphide and increases the carbon dioxide production. An increase in temperature or pH tends to decrease hydrogen sulphide and increase methane production. Particular attention has been given these considerations because of the possibility of utilizing this gas for power to furnish an additional air supply.

Hydrogen sulphide in appreciable quantities is, of course, corrosive to valves and cylinder walls of an internal combustion engine. Experiments are now under way with an automobile engine rebuilt to operate on gas, temporary means of heating the digester have been installed, and runs will be made with and without temperature and pH control. After each run the engine will be inspected for corrosion. If it is found feasible to utilize the digester gas for power, a gas engine will be installed to drive a 700-c.f.m. blower. The cooling water from this engine will be circulated through heating coils installed in the digester when it was constructed, and the temperature of the digester will be maintained at 80° F. These plans offer considerable possibility for

improvement in plant operation, as well as some reduction in operating costs.

Summarizing the year's experience with sludge digestion, a quick-drying sludge free from odors has been produced at all times, while foaming was encountered only once and that was of a mild nature, and was caused by drawing off too much sludge. The overflow liquor from the digester has been quite high in suspended solids at times, but has been handled on the sludge beds with no ill effects. Most of the sludge produced has been used as fertilizer, much of it around the plant on lawns and shrubs. The Park Board hauled a considerable portion into the city for use in parks and nurseries, and a small amount has been sold to farmers for use on lettuce fields. An income of $180 was received from this last source the first year. It is hoped as the farmers become better acquainted with the material that a considerable portion of it can be disposed of in this manner. At present the farmers pay 17c per sq. yd. for the sludge on the drying beds and remove it themselves.

Sewage aeration is accomplished by diffused air in spiral-flow tanks. There are two aeration tanks operated in parallel, each 24 ft. wide, 64 ft. long, and 12 ft. deep, with a baffle extending 56 ft. along the center of the tank, around which the sewage flows. Air, compressed by Connersville blowers, is introduced through two rows of filtros plates along each side of the center baffle, under a pressure of 5.6 lb. per sq. in.

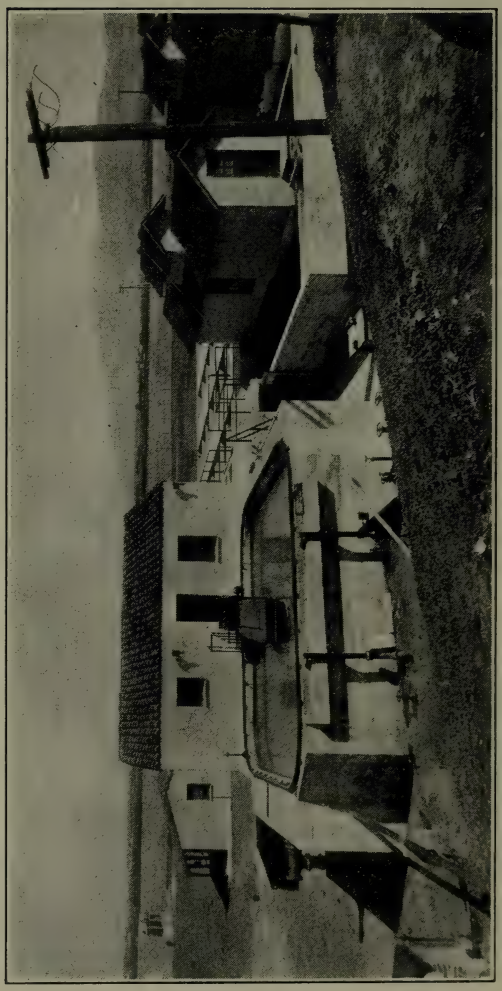
From the foregoing discussion of character of crude sewage and the percentages removed by preliminary sedimentation, it is evident that the Salinas sewage—even after receiving preliminary treatment—is very strong. A representative analysis of the settled sewage is shown in Table IV.

TABLE IV

	(p.p.m.)
Residue on evaporation	1178
Loss on ignition	519
Total suspended solids	173
Volatile suspended solids	156
Oxygen consumed	164
5-day B.O.D.	357
Organic nitrogen	20
Ammonia nitrogen	36
Nitrate nitrogen	0.2
Total grease	222

By way of comparison, this settled sewage is, on the basis of suspended solids, stronger than the crude sewages at 8 of the 15 plants reported on by the U. S. Public Health Service in "Public Health Bulletin No. 132." Also, on the basis of B.O.D. and the ether soluble matter, it is stronger than any of the 15 crude sewages.

The extraordinary strength of the sewage has caused considerable difficulty in the aeration process. The first trouble encountered was in building up an activated sludge. After several attempts, it was found impossible to build up a good sludge with continuous flow through the aeration tanks. Finally, all sewage flow was cut off the aeration tanks and their contents aerated for 3 days at an average rate of 560 cu. ft. of air per min. During this time the dissolved oxygen was increased



Primary Clarifier, Blower House, Final Clarifiers, and Aeration Basins, Salinas, California, Sewage Treatment Plant

from 0.6 to 5.9 p.p.m. For the next 3 days, the tanks were operated on a fill-and-draw schedule, adding 100,000 gal. of settled sewage a day and maintaining a high dissolved oxygen content at all times. A continuous flow of 25% of the total was then started through the tanks and 900 cu. ft. of air used continuously. As the amount of aerated sludge increased, the amount of sewage being aerated was also increased, and in this manner a good sludge was finally built up.

The next difficulty was a frequent bulking of sludge, with consequent poor clarification and loss of nitrification. The bulking, undoubtedly caused by the excessive strength of the sewage, indicated the need of enlarged capacity in the return-sludge system. This was accomplished by a slight piping change, increasing the capacity of the system to 75% of the average total sewage flow. Obviously, the total capacity is seldom used, but it adds greatly to the peace of mind of the operator to know that it is available when necessary.

At the same time, the practice of reaerating sludge was started by introducing the settled sewage into the aeration tanks at a point three-eighths of the way down one side, thus cutting the tank volume available for sewage aeration from 33,740 cu. ft. to 27,410 cu. ft. and providing 6330 cu. ft. for sludge reaeration. Simultaneously, experiments were undertaken with wooden baffles placed in the aeration tanks to deflect the rising air and mixed liquor above the filtros plates, and so bring more of the tank cross-section into effective use.

These various undertakings greatly improved operation and results, and increased the stability of the plant by increasing its capacity to handle strong sewage. Since they were started, the plant has produced a well clarified effluent, although relative stability and nitrification still vary between rather wide limits. Specifically relative stabilities have ranged from 11% to 99%, and nitrates from 0 to 16.5 p.p.m. Table V gives an average analysis of the final effluent, together with the overall percentage reductions through the plant.

TABLE V

	Average analysis of final effluent	Overall percentage reduction through plant
Residue on evaporation	940 p.p.m.	31
Loss on ignition or residue	280 p.p.m.	57
Total suspended matter	22 p.p.m.	94
Volatile suspended matter	16 p.p.m.	95
Oxygen consumed	96 p.p.m.	56
5-day B.O.D.	27 p.p.m.	94
Organic nitrogen	4 p.p.m.	83
Ammonia nitrogen	19.5 p.p.m.	54
Nitrite nitrogen	1.5 p.p.m.	....
Nitrate nitrogen	5.2 p.p.m.	....
Relative stability	53%	....

The solid content of the return sludge has varied from 0.3 to 1.6%. The rate of returning sludge is governed by the density, and hence the periods of aeration and reaeration have varied over a wide range. Under average conditions (49% return sludge) they have been 5.3 and 3.8 hours, respectively. Air consumption is 1,360,000 cu. ft. per day, or an average of 2.2 cu. ft. per gal. of sewage.

Experience seems to indicate that additional air supply is desirable. At the present time, because of limited blower capacity, air is introduced at a constant rate. The sludge deteriorates markedly through the day, but is usually rejuvenated during the night. Occasionally, too, serious bulking occurs, and at such times by-passing part of the flow to sand beds provided for the purpose is the only effective way of overcoming the difficulty. Utilization of digester gas has been considered since the plant was started, and augmentation of the air supply has been purposely deferred until complete data pertinent to such utilization can be obtained. If the experiments now in progress are successful, an engine-driven (gas) blower of 700-c.f.m. capacity will be installed, which would make it possible to vary the air input with the quantity and strength of the sewage. It is believed that more consistent results would thus be obtained, and that some reduction could be made in operating costs.

Final Clarification—From the aeration tanks, the mixed liquor flows to two final settling tanks operated in parallel. These tanks are equipped with Dorr center-drive sludge collection mechanisms, and have a total overflow weir length of 135 ft. 4 in. Under average conditions they have a theoretical detention period of 2.4 hours and a settling rate of 820 gal. per sq. ft. per day. The tanks have a side water depth of 12 ft., and this depth proved very useful during periods of bulking sludge, as it was possible to carry a 5 or 6 ft. sludge depth in the clarifiers without having floc pass over the effluent weirs.

Sludge is pumped from the final clarifiers by two Fairbanks-Morse variable-speed centrifugal pumps, and is discharged to the reaeration compartments or to the crude sewage over weirs, so that definite knowledge of the rates of returning and wasting sludge can always be obtained. Builders Iron Foundry orifice meters are used to measure and record the sewage flow and air consumption, and a meter is provided for measuring power used in pumping the crude sewage into the plant, as separated from power used for treatment proper.

The effluent flows from the final clarifiers through 1½ miles of pressure conduit to the Salinas river. In spite of the very low flow in the river this summer, it has been possible to maintain at least a 90% oxygen saturation content at all times.

Operating Costs—The power consumption at the Salinas plant is relatively high as compared with other plants, because of the strength of the sewage. About 23,000 kw.-hr. per month is used in treating the sewage and 3000 kw.-hr. for pumping crude sewage; average cost for the total power being slightly under $300 per month. It is estimated that utilization of the digester gas, if it proves feasible, will realize a saving in excess of $50 in monthly power bills in addition to supplying the additional air required.

Considerable laboratory and other experimental work in connection with sludge digestion, aeration and gas utilization has been carried on during the past year, in order to insure the greatest possible operating efficiencies in the future. Consequently, two men in addition to myself have been employed continuously at the plant. This work having accomplished its purpose can be considerably reduced on the

termination of experiments with gas utilization, making it likely that only two men will be required for operation. Certain additional labor has been required periodically, also, for removal of sludge and care of the grounds around the plant. Table VI summarizes annual operating costs for the past year.

TABLE VI

Power	$3600
Operating salaries	6000
Care of grounds and removal of sludge	600
Miscellaneous supplies and equipment	500

Acknowledgment—The plant was designed and built under the supervision of Burns-McDonnell-Smith Engineering Co., of Los Angeles and Kansas City; E. M. Funk was general contractor; Howard F. Cozzens is city engineer, and Donald Davies, Jr., is superintendent of streets and sewers. These men and the city council have given the consulting engineers the utmost support and cooperation at all times. I was in direct charge of construction and have been in charge of operation from the beginning.

ROSTER OF MEMBERS

Adams, W. H., Engineer with Sanitation Division, County Surveyor's office, 1633 Ard Eevin Ave., Glendale.
Albers, J. C., City Engineer, 1127 N. Geneva St., Glendale.
Allen, William A., Assistant Superintendent, Sewage Disposal Plant, 310 Ventura St., Pasadena.
Arndt, Charles, plumbing and heating, 110 Winston St., Los Angeles.

Banta, A. Perry, Engineer, Los Angeles County Sanitation Districts, 139 N. Broadway, Los Angeles.
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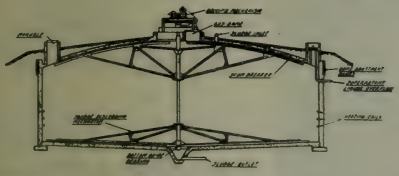

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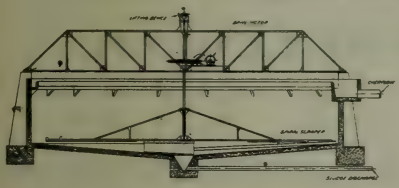
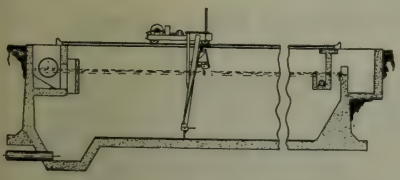


The central drive clarifier mechanisms are used in circular and square tanks. Where the square tank is used, the bottoms are rounded out by filling in the corners with sloping fills. An important feature of the central drive Clarifier is that it completely cleans the tank floor and removes the settled solids in a shorter period of time than is possible with other type of revolving mechanism with a minimum of mechanical disturbance. Bulletin No. 31.

Rectangular Clarifiers



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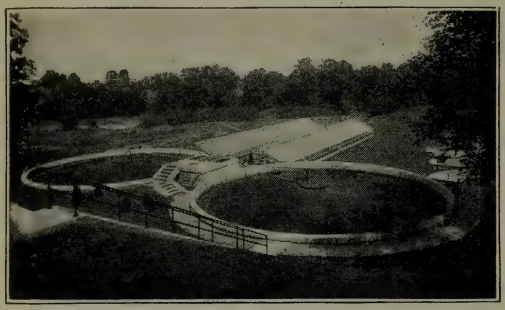

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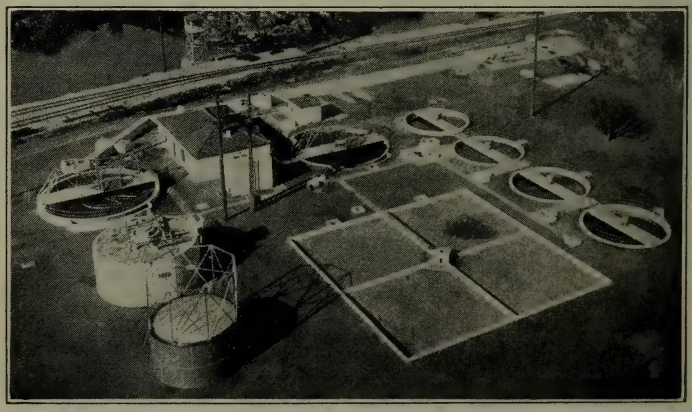

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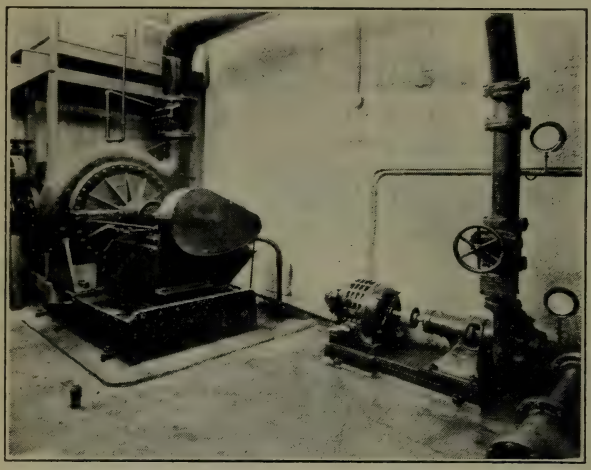

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CALIFORNIA SEWAGE WORKS JOURNAL

Official Publication of the California Sewage Works Association

Vol. V • 1932-33 • No. 1

Proceedings of the

Fourth Spring Conference at Yosemite Park,

Fifth Annual Convention at San Diego, and

Fifth Spring Conference at San Luis Obispo

●

Report Form for Award of Merit Committee

●

Sewer-Revenue Bond Act (A. B. 980) Outlined

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CALIFORNIA SEWAGE WORKS JOURNAL

Address all communications to the Secretary

Membership and Annual Dues $2.00

This Journal, together with the Journal of the Federation of Sewage Works Associations, free to members. Extra copies, $1.00.

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Printed by

WESTERN CONSTRUCTION NEWS AND HIGHWAYS BUILDER

114 Sansome Street, San Francisco, California

California Sewage Works Journal

Published by CALIFORNIA SEWAGE WORKS ASSOCIATION

The California Sewage Works Association is not responsible, as a body, for the supposed facts and opinions advanced in any of the papers, discussions, or articles published in this Journal. Discussion of all papers is invited.

VOL. V 1932-33 No. 1

TABLE OF CONTENTS

Officers, Directors, and Committees 6
California Sewer-Revenue Bond Act—*Clyde C. Kennedy* 7
Program of Fourth Spring Conference at Yosemite National Park 8
Minutes of Fourth Spring Conference 9
Obituary Resolutions for Philip Schuyler and Andrew Jensen 13
Report and Recommendation on Award of Merit for 1931 14
Operation of Yosemite Valley Activated Sludge Plant—*Russell C. White* 17
City of Lodi Activated Sludge Plant—*Fred W. Post* 25
Pasadena Activated Sludge Plant—*A. W. Wyman* 26
Salinas Activated Sludge Plant—*T. R. Haseltine* 27
Los Angeles County Sanitation Districts' Activated Sludge Plant—*A. P. Banta* 31
Grand Canyon Activated Sludge Plant—*Hilliard Hall* 33
Operation of Los Angeles County Sanitation Districts Sewer System—*Fred D. Bowlus* 36
Glendale Sewer System Operation—*J. C. Albers* 38
Operation of Sacramento Sewer System—*Carl M. Hoskinson* 39
Unusual Operating Experiences, City of Los Angeles—*F. A. Batty* 41
Operation of Oakland Sewer System—*T. F. Eastman* 42
Odor Control at Whittier Sewage Disposal Works—*Alva J. Smith* 44
Improvements at Tulare Municipal Sewer Farm—*W. M. Brown* 49

Table of Contents (Continued)

1932 Yosemite Spring Conference Papers Published in 'National Federation Journal' 52
Program of Fifth Annual Convention at San Diego 53
Minutes of Fifth Annual C.S.W.A. Convention 54
Demonstration on Bulking and Debulking of Activated Sludge at Escondido Plant—*R. F. Goudey* 61
San Diego State Teachers' College Plant—*B. D. Phelps* 63
Sewage Analyses and What They Tell the Operator—*E. A. Reinke* 64
Discussion—*R. F. Goudey* and *Jane H. Rider* 74
Unusual Conditions Encountered in California Sanitary Sewer Design and Construction—*Charles H. Lee* 77
A Sanitary Correspondence—'Steve' to 'Al', or As One Sewer Rat to Another—*Leon B. Reynolds* 83
Discussion of Goudey's Yosemite Spring Conference Paper—*Wm. Gavin Taylor* 89
Discussion of Hyde's Yosemite Spring Conference Paper—*Paul J. Beard* 92
1932 San Diego Annual Convention Papers Published in 'National Federation Journal' 95
Operating Experiences at Phoenix, Arizona, Activated Sludge Plant—*D. Travaini* 96
Discussion—*Jane H. Rider* 104
Possible Pollution of Water Through Use of Toilet Flush Valves—*Walter Putnam* 106
Field Experiments in Problems of Water Contamination from Private Flush Valves—*Jean Vincenz* 110
Program of Fifth Spring Conference at San Luis Obispo 113
Minutes of Fifth Annual Spring Conference 114
Sewage Screenings Disposal—*J. J. Jessup* 118
Incineration of Sludge—*R. F. Goudey* 125
Cross-Connections Between Water and Sewage Systems—*Ray L. Derby* and *C. W. Sopp* 127
1933 San Luis Obispo Spring Conference Papers Published in 'National Federation Journal' and in 'Western Construction News and Highways Builder' 131
Hazards, Gas Masks, and First Aid—*Fred D. Bowlus* 132
Changes in Character of Sewage—*F. S. Currie* and *W. C. Roberts* 136
Keeping Down Power Costs—*H. K. Palmer* 142
Title of A. B. 980—The California Sewer-Revenue Bond Bill 144
Tax Delinquencies in Sanitary Districts—*C. R. Compton, D. E. Perry,* and *G. C. Zuckweiler* 145
Index to Advertisers 150

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CALIFORNIA SEWER-REVENUE BOND ACT

By CLYDE C. KENNEDY*

Passage of the Sewer Revenue Bond Act marks a definite change in the basis of consideration of sewage works in the state of California. While this act was passed for the definite and restricted purpose of providing a method of financing such works from funds made available by the federal government in the act of 1932, popularly known as the 'Emergency Relief & Construction Act', it establishes the principle of construction and operation of sewage works from funds secured by charges for the use of the facilities provided by the residents, commercial houses, and industries served. The widest latitude is given in fixing the scale of charges, authority for which is vested exclusively in the local authorities constructing the project, so that, for each community, the cost of construction and operation may be distributed equitably on the users of the works.

The act, briefly, provides that authority shall rest originally with the governing body of any municipality or district to pass a resolution of intention to issue bonds for the construction of sewage works in accordance with plans and specifications which have already been prepared as preliminary to the passage of the resolution. The report of the engineer accompanying the plans and specifications shall set forth the estimated cost of the works, area to be served, and the estimated revenues. Unless the referendum shall be invoked, the passage of the resolution, after proper hearing, shall give authority to issue and sell the bonds in the amount set up in the estimate. Thereafter, the bonds are to be sold to the federal agency. If the referendum is invoked, an election must be held and the project approved by the majority of the land owners within the area to be served. With this procedure, the project may be pushed to the construction stage much more quickly than under the existing bond acts, thereby making such projects a means of providing emergency employment.

It is mandatory on the governing body to set up a schedule of charges which will provide funds for the proper operation of the works constructed, and for the interest and principal of the bonds issued for the cost of the works. To those interested in the proper operation of sewage treatment plants, the first of these provisions is most important. For the first time, a definite source of revenue for treatment plants is assured. The disheartening story of works, conceived, constructed, and placed in operation in high enthusiasm, only to have some succeeding city council or district board destroy their effectiveness by failure to provide sufficient funds for proper operation and maintenance, is too well known to require repetition.

With the new legislation, sewage works may be constructed with the certain knowledge that ample revenue will be available for their proper operation and that the cost of such operation can be placed on the users of the works in proportion to the load which they place on the plant. These two objectives have been sought for many years by engineers and sewage plant operators as necessary if sewage treatment plants are to be successfully operated and maintained. If the soundness of these principles can be successfully demonstrated during the limited life of the existing Sewer Revenue Bond Act, there should be no difficulty in securing their continuance.

* Northern California Chairman, Legislative Committee, California Sewage Works Association; Consulting Engineer, San Francisco.

1932 SPRING CONFERENCE

Yosemite National Park

May 20-21, 1932

Headquarters, Yosemite Lodge

Program

FRIDAY, MAY 20

8:00-10:30 a. m.—Inspection of new Yosemite activated sludge plant.

11:00-12:00 —Inspection of equipment in automobile camp grounds, incinerator, can-baling machine, and garbage-can washing apparatus.

12:15 p. m. —Lunch at Yosemite Lodge cafeteria.

2:00- 5:00 p. m.—Address of welcome by Col. C. G. Thompson, park superintendent.

Paper on 'Activated-Sludge Sewage Treatment Plant in Yosemite National Park', by Russell C. White.

Discussion by plant operators of special features and operating problems at activated-sludge sewage treatment plants.

(a) Griffith Park Station, Los Angeles, by S. M. Bennett.
(b) City of Lodi, by Fred W. Post (read by secretary).
(c) City of Pasadena, by A. W. Wyman.
(d) City of Salinas, by T. R. Haseltine.
(e) Los Angeles County Sanitation Districts, by A. P. Banta.
(f) Grand Canyon National Park, by Hilliard Hall (read by H. B. Hommon).

Symposium on 'Unusual Experiences in Operation of Sewer Systems'

(a) City of Los Angeles, by F. A. Batty.
(b) Los Angeles County Sanitation Districts, by Fred D. Bowlus.
(c) City of Glendale, by J. C. Albers.
(d) City of Sacramento, by C. M. Hoskinson.
(e) City of Oakland, by T. F. Eastman.
(f) City of Fresno, by W. F. Rantsma.

7:00 p. m. —Outdoor barbeque at Indian Caves.

Address by D. Tresidder, general manager, Yosemite Park & Curry Co.

Address by Bert Harwell, park naturalist, on 'Formation of Yosemite Valley'.

SATURDAY, MAY 21

7:30- 8:30 a. m.—Sunrise trip to Mirror lake and visit to fish hatchery.

9:00-12:00 —Business meeting, with reports of legislative, publicity, and resolutions committees and award of merit (to Pomona plant).

Papers on: 'Activated Sludge Sewage Treatment Plant at Folsom Prison', by L. E. Rushton.

'Odor Control at the Whittier Sewage Treatment Plant', by Alva Smith.

'Digestion of Bar Screenings', by A. M. Rawn.

'Digestion of Garbage in Beccari Cells, with Analogies to Sludge Digestion Problems', by Charles Gilman Hyde.

'Improvements at Tulare Sewer Farm', by W. M. Brown.

'New Thoughts in Sedimentation of Sewage', by Chester A. Smith.

'New Thoughts in Sludge Digestion and Disposal', by R. F. Goudey.

1:00- 5:00 p. m.—Inspection of camp ground at Mariposa Grove of Big Trees, including water supply, sewerage, and sewage disposal.

FOURTH ANNUAL C. S. W. A. SPRING CONFERENCE AT YOSEMITE, MAY 20-21, 1932

By E. A. REINKE†

Morning Session, May 20, 1932

About 100 members and guests of the California Sewage Works Association assembled at the Yosemite Park activated sludge plant, located south of Merced river near Bridal Veil falls. The plant location was chosen to meet rigorous requirements of freedom from odors and noise, and is out of sight of roads and trails. It consists of a plain hopper-bottom settling tank; four aeration units equipped with Norton plates (air being furnished by two General Electric centrifugal blowers), and designed for Manchester-type aeration—one unit can be used for reaeration; two Dorr clarifiers in series, the second serving also as a chlorine contact tank; an automatic Wallace & Tiernan chlorinator for regular use, with a portable machine for standby emergency service; separate sludge digestion tanks with gas collection and heating, but no mechanical stirring; a sludge-thickening tank for raw or activated sludge; and a glass-covered sludge drying bed.

The plant is well arranged, neatly kept, and aroused favorable comment from the convention delegates. Particular comment was heard on the use of continuous streams of effluent from the two clarifiers for sampling at a table similar to that at a water filter plant, and a vacuum gauge with colored liquid, at the same table, to indicate the chlorine feed at any given time. A float gauge on the effluent weir gives readings of sewage flow leaving the plant.

A caravan was formed at the plant, led through typical camp grounds of the park, and stopped at the incinerator where a garbage-can washing apparatus and can-baling machine were demonstrated to the members.

Members met in informal groups for lunch.

Afternoon Session, May 20, 1932

The meeting was called to order by president Allen. Harry B. Hommon, chairman of the committee on program and local arrangements,‡ was introduced and he in turn introduced C. G. Thompson, superintendent of Yosemite National Park, who welcomed the California Sewage Works Association to the park and praised Hommon's work in sanitation of parks, mentioning with particular pride the new sewage disposal plant in Yosemite valley.

An excellent paper, 'Activated-Sludge Sewage Treatment Plant in Yosemite National Park,' was read by Russell C. White, operator. Discussion following this paper included (a) 'Griffith Park Experi-

† Secretary-Treasurer, California Sewage Works Association, Berkeley; Senior Sanitary Engineer, Bureau of Sanitary Engineering, State Department of Public Health.

‡ Committee members were E. M. Hilton, A. M. Rawn, M. L. Crist and A. W. Wyman.

ment Station, Los Angeles,' by S. M. Bennett, chief operator; (b) 'Activated-Sludge Sewage Treatment Plant, Lodi,' by Fred W. Post, superintendent (read by the secretary); (c) 'Activated-Sludge Sewage Treatment Plant, Pasadena,' by Alfred W. Wyman, superintendent; (d) 'Activated-Sludge Sewage Treatment Plant, Salinas,' by T. R. Haseltine; (e) 'Activated-Sludge Sewage Treatment Plant, Los Angeles Sanitation District,' by A. P. Banta; (f) 'Activated-Sludge Sewage Treatment Plant, Grand Canyon National Park, Arizona,' by Hilliard Hall, operator (read by H. B. Hommon).

Others taking part in the discussion were W. A. Allen, A. J. Smith, and W. C. Roberts. The latter had just returned from Phoenix, Arizona, where he reported excellent results were being obtained with paddle aeration in addition to diffused air, using about 0.25 cu.ft. of free air per gallon.

The symposium 'Unusual Experiences in the Operation of Sewer Systems,' by F. A. Batty, Los Angeles; F. D. Bowlus, Los Angeles County; J. C. Albers, Glendale; C. M. Hoskinson, Sacramento; T. F. Eastman, Oakland; and W. F. Rantsma, Fresno; brought forth many interesting and instructive observations. An entertaining talk on political experiences was given by S. H. Davis, of Glendale. D. E. Perry, of San Anselmo, asked for information on per capita cost of sewerage and sewage disposal at various places and was given the information in a few instances.

The meeting adjourned until May 21 at 9 a.m.

Evening Outdoor Barbecue, May 20

One hundred and eight members and guests attended the outdoor barbecue at Indian caves. After a hearty repast, president Allen introduced H. B. Hommon and turned the evening over to him. Park officials who contributed so freely of their time and energy to make the meeting a success were introduced. D. Tresidder, general manager of the Yosemite Park & Curry Co., gave a delightful talk and offered the fullest cooperation of the company in making our stay enjoyable. He referred to the sewage disposal problem as having been 'solved' about every ten years in the history of the Yosemite valley and expressed the hope that the new plant would prove the final solution.

Bert Harwell, park naturalist, was then introduced. He entertained with a talk on the formation of Yosemite valley, led community singing, presented his nephew in violin solos, a quartet in popular songs, and gave a few whistling solos. He also chose a place to view the 'fire fall' from Glacier point at 9 p.m. This event was especially arranged for the C.S.W.A. through the courtesy of park officials and was a fitting climax to an eventful day and evening.

After the regular program some of the members were shown through the Park museum, which was opened for their benefit. Others visited the bear pits to watch the evening feeding of the bears.

Morning Session, May 21, 1932

The meeting was called to order by president Allen.

J. C. Albers, chairman, reported for the legislative committee that five meetings had been held with the legislative committee of the League of California Municipalities on sewer rental, and that a further report would be prepared for the annual fall meeting.

John Spencer, chairman, reported some difficulty with publicity to date. He urged each member to give his local paper a short story of the Yosemite meeting.

Charles Gilman Hyde, chairman, read the report of the committee of award of merit for 1931, which decided in favor of Pomona, largely because of the development of revenues from sewage and also for its excellent records, with honorable mention to Escondido. President Allen announced that the board of directors had decided in the absence of a contribution as received in past years to award $25 cash from the association funds. A. M. Rawn moved that the association grant the cash award and this motion was seconded and carried. The secretary explained that in view of previous cash awards the committee had announced that one would be given and the board felt this promise should be kept by the association. In answer to a question from the floor, president Allen stated that the cash award was given to the operator of the plant and not to the city.

H. F. Gray reported for the resolutions committee consisting of L. B. Reynolds, C. A. Smith, and himself, presenting written resolutions in memory of two of our deceased members, Philip Schuyler and Andrew M. Jensen. These resolutions were adopted and the members stood silent for a few moments in respect to their memory.

Gray also paid a high tribute to professor Charles Gilman Hyde for his many years of pioneer work in sanitary engineering in the west. Gray was a member of the first graduating class in sanitary engineering at the University of California a quarter-century ago and the progress during the past 25 years he considered truly remarkable, and largely due to the original work of professor Hyde.

Professor Hyde responded briefly by telling of the satisfaction he had of seeing his former students at work in the sanitary engineering field, which he said was the greatest satisfaction men like professor Reynolds at Stanford and himself could get from their teaching.

Alva J. Smith spoke briefly of the sanitary engineering progress in California during the ten years since he came to the state. He noted that we had a paper on one activated-sludge plant and discussion by operators from six others. He believed there was not a single activated-sludge plant in California ten years ago. When corrected, Folsom prison having constructed a plant in 1917-18, president Allen interrupted to remark that never having been in there Smith, of course, could not have been expected to know of the plant.

The secretary was instructed to send suitable letters to the local committee, park officials, and company officers who did so much to make our visit to Yosemite a pleasant and profitable one.

Papers were presented as follows: (1) 'Activated-Sludge Sewage Treatment Plant at Folsom Prison,' by L. E. Rushton; (2) 'Odor Control at the Whittier Sewage Treatment Plant,' by Alva Smith; (3-a) 'Digestion of Bar Screenings,' by A. M. Rawn (discussion by F. A. Batty and T. R. Haseltine); (3-b) 'Digestion Garbage in Beccari Cells, with Analogies to Sludge Digestion Problems,' by Charles Gilman Hyde (discussed by J. C. Albers and A. M. Kivari); (4) 'Improvements at Sewer Farm at Tulare,' by W. M. Brown, city manager; (5) 'New Thoughts in Sedimentation of Sewage,' by Chester A. Smith; (6) 'New Thoughts in Sludge Digestion and Disposal,' by R. F. Goudey.

President Allen announced that owing to the short time available the papers by C. A. Smith and R. F. Goudey would be printed and distributed as soon as possible and time allowed for their discussion at the San Diego meeting in September.

The meeting adjourned at 12:30 p. m. Total attendance at this spring conference was 134 and included the following:

Attendance at C. S. W. A. Yosemite Conference

J. C. Albers and wife, Glendale.
W. A. Allen and wife, Pasadena.
H. O. Banks, Stanford.
A. P. Banta, Los Angeles County.
W. Bardin, Stanford.
F. A. Batty and wife, Los Angeles.
P. S. Beard and wife, Stanford.
W. E. Bedesen, Merced.
S. M. Bennett and wife, Los Angeles.
A. C. Beyer, San Francisco.
M. R. Bowen, Whittier.
F. D. Bowlus, Los Angeles.
J. Branchsean.
W. M. Brown, Tulare.
J. F. Byxbee, Palo Alto.
A. R. Carlson, U.S.P.H.S.
J. A. Clark, Hayward.
Joseph P. Cleary, Stanford.
A. C. Cowell, Berkeley.
Sam Davis and wife, Glendale.
E. Dolliver, San Francisco.
A. L. Drown and wife, Ojai.
T. F. Eastman, Oakland.
J. Emmert, U.S.P.H.S.
L. J. Gale, Oakland.
R. F. Galeria, Atwater.
R. J. Gillespie, Los Angeles.
R. F. Goudey and wife, Los Angeles.
H. F. Gray, Berkeley.
C. H. Gwynn and wife, Auburn.
J. D. Hall, Los Angeles.
F. V. Hammerly, wife, and daughter, San Francisco.
T. R. Haseltine, Salinas.
C. P. Hauck and wife, Yosemite.
E. M. Hilton, Yosemite.
H. B. Hommon, U.S.P.H.S.
O. C. Hopkins, U.S.P.H.S.
C. M. Hoskinson and wife, Sacramento.
C. G. Hyde, Berkeley.
Helen Hyde, Berkeley.
Katharine Hyde, Berkeley.
John Jacobson, wife, and daughter, Davis.
T. P. B. Jones, Riverside.
N. W. Kelch, Los Angeles.
N. J. Kendall, Stanford.
A. M. Kivari and wife, Los Angeles.
G. Kjellberg, Riverside.
A. H. Koebig, Los Angeles.
H. Layne, Stanford.
N. L. Lelean and wife, Redlands.
Robert Linton, Los Angeles.
Walter Little, Stanford.
John L. Mason, San Francisco.
D. C. McMillan, Ventura.
F. E. Miick and wife, San Francisco.
R. E. Mittelstaedt and wife, Sacramento.
A. R. Neves, Atwater.
L. Olsen, Palo Alto.
H. K. Palmer, Venice.
B. J. Pardee and wife, Visalia.
H. Parkes, Sequoia National Park.
D. E. Perry, San Anselmo.
W. B. Phillips, Los Angeles.
G. C. Prior, Riverside.
Pyle and wife, Redlands.
W. F. Rantsma, Fresno.
A. M. Rawn and wife, Los Angeles.
E. A. Reinke and wife, Berkeley.
L. B. Reynolds and wife, Stanford.
R. R. Ribal, Oakland.
W. C. Roberts, San Francisco.
W. H. Rockingham, Sacramento.
L. E. Rushton, Sacramento.
A. Segel, wife, and daughter, Fresno.
J. G. Shattuck, Palo Alto.
H. S. Shilko and wife, Yosemite.
H. W. Shook, San Francisco.
C. Sloan and wife, San Francisco.
A. J. Smith and wife, Pasadena.
C. A. Smith and wife, Los Angeles.
J. F. Smith and wife, San Francisco.
J. Spencer, San Francisco.
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C. R. Willette, U.S.P.H.S.
A. W. Wyman and son, Pasadena.
John C. Young, Stanford.

RESOLUTIONS

(Yosemite Spring Conference, 1932)

WHEREAS, since the last meeting of this California Sewage Works Association death has removed from our membership our friend Philip Schuyler, whom we affectionately called Phil;

AND WHEREAS, he was influential in the organization of this association; in his capacity as an officer contributed his wise counsel toward its successful functioning; bore much of the responsibility for the regular issuance of our journal, and with enthusiastic vision insisted upon keeping the Far West clean;

NOW THEREFORE, BE IT RESOLVED that this association hereby expresses its sincere appreciation for his unselfish expenditure of time and energy in connection with its activities and that we as members and friends express our personal appreciation for his genial friendship;

AND FURTHER, BE IT RESOLVED that this resolution be spread upon the minutes of this association and a copy sent to his widow and daughter.

WHEREAS, within the past month the California Sewage Works Association has lost from its membership by reason of death in line of duty, Andrew Jensen, respected by all who knew him and beloved by those who have had the opportunity of working and associating with him;

AND WHEREAS, Andrew Jensen has been identified with this association since its inception as a member of the preliminary organization committee, as the chairman of the committee on arrangements for the Fresno meeting, and more recently as the representative of the Clay Products Association, and through these activities has become well known to all of us;

NOW THEREFORE, BE IT RESOLVED that this association expresses its regret at the untimely death of our friend and fellow member Andrew Jensen, and directs that this resolution be spread upon its minutes and a copy thereof sent to the bereaved family.

REPORT AND RECOMMENDATION ON AWARD OF MERIT FOR 1931

Report of Committee*

In November 1931 the Committee on Award prepared: (1) a circular letter concerning the Award of Merit by the California Sewage Works Association for the year 1931; (2) a form of declaration of entrance of sewage treatment plants in competition for the award; (3) a data sheet concerning sewage treatment plants entered in competition for the award. In November the circular letter and the declaration form were mailed to all clerks of communities in the state provided with sewage treatment plants, and to all secretaries of sanitary districts wherein such plants were in operation.

In response to the circular letter, eight declarations of entrance into competition for the award for the year 1931 were returned. Unfortunately two of the eight plants could not be considered, because they had been in operation during only a part of the year. One declaration was received too late to permit the community to be eligible, since the latest date set for the return of applications was January 15, 1932. To the other five communities data sheets were sent and four of these were returned properly filled out.

Consideration was therefore given by the committee to the relative and absolute merits of the four plants for which all of the terms of the competition as set by the committee had been fulfilled.

None of the four plants in question, in the opinion of the committee, quite measured up to the ideal which was evidently in the minds of those who planned the award as a means of encouraging progress and a higher plane of achievement for the sewage treatment plants of the state. The more pronounced shortcomings may be stated as follows: (1) Inadequate maintenance; (2) Lack of orderliness, or what may be termed good housekeeping.

All of the plants in question have performed creditably with respect to the things which were absolutely required to be done. All had been operated throughout the year in such a way as to secure the quality of effluent which was needful, and for which they were designed.

The shortcomings of the plants entered into the competition are typical of many, if not most of the others in the state. There is a sort of unnatural and unnecessary drabness about our sewage treatment plants in general. The simple rules of good housekeeping are not enforced. The lack of real enterprise and pride in the plant is usually all too apparent. Exposed piping and machinery are permitted to rust, and what paint remains is too often old and dusty. Weeds are frequently more in evidence than are the few flowers among

* Committee composed of Charles Gilman Hyde, chairman; Leon B. Reynolds; and C. G. Gillespie.

which they are allowed to grow. Windows are often broken, almost always unclean, and sometimes covered with spider webs. Laboratory glassware and utensils are far too frequently dirty, and the labels on bottles scarcely discernible. On the premises old lumber, cans, and tools stare one in the face and make a very bad impression.

Recommendation

It is recommended that the award for 1931 be made to the city of Pomona† and that honorable mention be made of the city of Escondido.

With respect to final effluent, the two treatment plants are about equivalent. There were two factors, however, which have determined in favor of the city of Pomona. These are, first and by far the most important, that the city has developed the revenue phase of its plant and sewage treatment to a commendable extent, and second, that the records of operation are more complete and satisfactory than are those for the plant of the city of Escondido.

Respectfully submitted,

COMMITTEE OF AWARD FOR THE YEAR 1931.

By Charles Gilman Hyde, *Chairman.*

Notice from Committee to City Clerks and Sanitary District Secretaries

In 1929, the California Sewage Works Association was the recipient of an offer to provide annually a medal and a gift of money to constitute an Award of Merit to the most meritorious plant of the year, judged upon the basis of the following principal considerations:

(1) Intelligent and conscientious operation.

(2) Efficient results.

(3) Good appearance.

(4) Local support, interest, and pride in plant.

(5) Excellence of design.

All plants in the state are eligible for consideration, the only requirements being that the city or district officials shall: (1) declare on the accompanying form that they desire to enter their plant in competition for the award, and (2) at a later date, upon request of the committee, fill out a data sheet.

The award will be made public at the forthcoming spring meeting of the association.

† Moved and seconded that award be made to Pomona and $25 appropriated from C. S. W. A. treasury for cash prize.—Editor.

Data Sheet Concerning Sewage Treatment Plants Entered in Competition for the 1931 Award

1. Name of Community, District or Plant .....

2. Population (a) served at present .....
   (b) provided for in design .....

3. Type and features of plant (designate by an X opposite the features incorporated in plant)
   (a) Bar Screens (hand cleaned) .....
   (b) Bar Screens (mechanically cleaned) .....
   (c) Septic Tank .....
   (d) Imhoff Tank .....
   (e) Dortmund-type Tank .....
   (f) Primary Clarification Tank .....
   How cleaned .....
   (g) Separate Sludge Digestion .....
   Gas Collection .....
   (h) Activated Sludge .....
   (i) Trickling Filter .....
   (j) Intermittent Sand Filter .....
   (k) Broad Irrigation (sewage farm) .....
   (l) Secondary Settling Tank .....
   (m) Sewage Oxidation Ponds .....
   (n) Sludge Drying Bed .....
   (o) Other Sludge Drying Methods .....
   (p) Chlorination (a) for odor control .....
   (b) for disinfection .....
   (q) Method of Disposal of Effluent .....
   (r) Method of Disposal of Sludge .....
   (s) Other Features Not Above Included .....

4. (a) When Constructed, Originally .....
   (b) When Extended .....
   (c) Acreage for Plant and Disposal .....
   (d) Experimental or Test Work Leading to Design .....
   (e) Enumerate Industrial Wastes with which Plant has to contend and Special Measures for Dealing with Them .....

5. (a) Original Cost of Construction of Treatment Plant, Exclusive of Outfall Sewer and Land .....
   (b) Cost of Extension to Treatment Plant, only .....
   (c) Cost of Land .....

6. Expenditures 1928 1929 1930 1931 1932
   (a) Bond Redemption .....
   (b) Interest .....
   (c) New Construction (explain) .....
   (d) Gross Maintenance and
   Operation 1928 1929 1930 1931 1932
   Labor .....
   Power .....
   Supplies .....
   Beautification .....
   Miscellaneous .....
   Total .....
   Revenue (Effluent) .....
   (Sludge) .....

7. Operating Staff—Number, and Percentage of Time Employed and Salaries Paid to Each.....
   Previous Experience of Each Operator or Basis for His Selection.....

8. Records Kept .....

9. Analytical Control. Tests and Frequency of Same. Results Shown.....
   Please submit typical examples of records and results (additional data may be requested at a later date).

10. Beautification of Plant .....

11. Describe in Detail Program of Betterment in Plant and Its Operation in Recent Years with Particular Reference to "Award" Consideration.

12. State what Degree of Interest in the Plant is Shown by the Citizens and Visitors from Other Places, Expressed by Numbers of Visitors and Otherwise.

13. Name and Title of Person Submitting the Above Information.

OPERATION OF YOSEMITE VALLEY ACTIVATED SLUDGE SEWAGE TREATMENT PLANT

By RUSSELL C. WHITE*

The sewage produced in Yosemite valley is treated in an activated-sludge plant with separate sludge digestion and glass-covered sludge beds. The plant was designed to treat 1.224 m.g.d. of sewage, which is 100% more than the average flow for June, 1931, the month when the largest volume of sewage is produced in the valley.

Since a detailed description of the plant and its component parts has been published,† this paper will describe plant operation from the time it was started in August 1931 to May 1932.

On August 8, 1931, two of the aeration tank units were filled with sewage and aerated about 20 hours. The following day the air was shut off from the tanks, suspended solids were allowed to settle, and 50,000 gal. of sewage was added. This procedure was followed daily until August 30, when there was 15% of activated sludge by volume in the aeration tanks. In the meantime, by pumping sludge from the hoppers of the pre-settling tank to the tank influent, all of the suspended matter in the raw sewage was added to the aeration tanks.

Air Supply—Due to operating difficulties, it was necessary on August 28 to return to the factory the blowers installed when the plant was constructed. Air for the aeration tanks during the next 3 months was supplied by a compressor which had been used in the park for various purposes. The compressor capacity was 265 c.f.m., which was only a little more than half the capacity of each blower and about half the amount required to operate two of the aeration units. Up to this time, raw sewage was applied to two units of the aeration tanks, but on account of the small amount of air available it was necessary to drain one of the aeration units and aerate sewage in the other unit. One of the blowers was repaired and returned on December 2 and placed in service.

Between August 28 and September 14, about 75% of the sewage was treated, and on September 15 all the sewage was turned into the plant. Since that date no sewage has been diverted to the old treatment plant, except on two occasions when it was necessary to empty the clarifiers to recover tools that had fallen into them.

Volume of Sewage—Practically all of the sewage produced in the valley is collected in a sump and pumped to the outfall, where it flows by gravity to the treatment plant. Under these conditions the plant receives daily—for a short period at least—the maximum capacity of the pumps, which is 850 g.p.m. or a rate of flow of 1.2 m.g.d. This rate is the maximum capacity for which the treatment plant was designed. Intervals between pumpings vary with the amount of sewage produced. Since the plant was placed in operation, the average flow

* Operator in charge of Yosemite Valley Sewage Treatment Plant.

† Hommon, H. B., 'California Sewage Works Journal,' Vol. IV, No. 1, Sept. 1931, p. 51-52, and 'Western Construction News,' January 25th, 1932, p. 53-59.

has been 0.25 m.g.d., with a minimum of 0.15 and a maximum of 0.5 m.g.d. The sewer line between the pumps and treatment plant is 4 mi. long and the gradient averages 0.1%. This length of line and the low gradient tends to reduce the volume during peak flows below the actual rate of pumping.

Coarse Bar Screens—There are two coarse bar screens, one with 3-in. and the other with 2-in. openings, designed primarily to retain materials that would tend to clog the siphon which starts at the screen chamber and passes under Merced river to the pre-settling tank. These screens are so arranged that pieces of wood, or other materials of similar nature, longer than 12 in., will be retained regardless of diameter. The screen chamber was also designed as a grit chamber to retain sand or gravel that might enter the line either from surface washings or through a break.

Most of the material removed from the screens has been a heavy growth of leptomitus, which first made its appearance in November, 1931, and reached its maximum in March, 1932. When the plant was first placed in operation, screenings were hauled to the garbage incinerator and burned. On account of the expense of hauling and the difficulties of burning screenings, they were later buried in trenches near the screen chambers.

The pre-settling tank is rectangular in shape, has a concrete cover, four hopper bottoms, and an overflow weir, and has a minimum detention period of 45 minutes when receiving the maximum designed sewage flow. From each hopper there is an outlet which connects with a line to the sludge-thickening tank.

Since it was considered necessary to cover the tank to reduce odors, surface baffles had to be omitted because they would collect scum that could not be removed.

In operation of the treatment plant as a whole, there is returned to the raw sewage entering the pre-settling tank: (1) liquors from the digestion tanks; (2) sludge from the final clarifier; (3) supernatant sewage from the sludge-thickening tank; (4) activated sludge from the aeration tanks when it becomes necessary to empty these tanks; (5) wastes from the laboratory, and all other places where sewage escapes or is taken out for various purposes; and (6) filtrate from the sludge-drying beds.

The sludge is discharged from the hoppers by gravity to the thickening tank twice daily during warm weather, and once a day during the winter.

The amount of settleable suspended solids removed by the pre-settling tank has averaged 67% and the pH of the effluent has been around 6.8, which is practically the same as that for sewage entering the tank. There has been no perceptible odor either from raw sewage entering the tank or the effluent discharged from it.

The aeration tanks, which are of the spiral flow-type, consist of four units, each with 80,000-gal. capacity and having in the floor two continuous channels with porous plates at the top for applying air to the sewage. The tanks are so arranged that the first two can be

operated either in series or parallel, but the other two can be operated only in series with no. 1 and no. 2, as four units, or with no. 2 as three units.

Air is delivered to the ends of the channels under Norton porous plates with a rating of 17½ to 22½ c.f.m. of air under a 2-in. water pressure, by two General Electric centrifugal compressors. Each compressor has a capacity of 425 c.f.m. under 6½ lb. per sq. in. pressure at elev. 4000 ft. and a temperature of 72°F.

On account of the difficulties experienced in operating the blowers, it was not possible to operate either no. 1 or no. 2 units of the aeration tanks continuously. When the plant was first started, the two units were operated in series. This practice had to be changed and one or two units used either separately or in series, depending on the amount of air available from the compressor, and the clogging of the plates.

Since chlorine is applied to the influent of the final clarifying tank, activated sludge is returned to the aeration tank only from clarifier no. 1, which receives effluent from the aeration tanks. About 20% activated sludge has been maintained in the aeration tanks, as this amount has produced the most satisfactory effluent.

Clogging of Porous Plates—The only serious difficulty encountered in operation of the aeration tanks was clogging of the porous plates, due largely to oil carried with the air from the compressor used when the blowers were out of service. There was a small oil trap on the pipe-line from the compressor, but this failed to remove fine particles of oil. Solvents which were passed through the porous plates receiving air from the compressor contained 6½% ether soluble matter. During the first six months the aeration tanks were in operation, it was necessary to shut the air off from the tanks at frequent intervals. It is believed that suspended matter passed into the plates and was a contributing factor to the clogging.

Many different methods and materials were used to restore the plates to their original porosity. The first attempt included emptying the tank, drying the plates, and scrubbing them with a wire brush, applying hydrochloric acid in different concentrations, and scrubbing and washing with hot concentrated solutions of alkaline compounds. The acid, when applied in different dilutions to plates removed from the channels and to the plates in place, readily passed through the plates but did not remove material in the voids. The washing compounds, when dissolved in boiling water, would not pass through the plates, even when rubbed over the surfaces with brushes. Hot and cold water applied to the top surfaces of the plates remained standing in pools and would not filter through.

Since examination of the plates showed that they contained oil, denatured alcohol was applied to the top surfaces of both the plates in place and also ones that had been removed from the channels. The alcohol passed through these plates, but not as freely as through those that had not been used. Although the alcohol removed the oil, the resistance to the flow of air through the plates was still too high.

The flame from a blow torch was then applied to the top surfaces of the plates in place until the color turned to dark brown. The heating, however, was never continued until there was fusion of the surface particles of the plates or until the plates cracked. Treatment of the plates with 1 pint of alcohol and burning with a torch opened the voids so that the initial loss of pressure due to friction was 18 in. of water, as compared with 14 in. for plates in place that had not been used. The plates were tested while they were wet and passing 6 c.f.m. of air per plate.

Sludge Return—The original design of the air lift for returning sludge from the first clarifier to the aeration tanks included a drop pipe inside the sludge-discharge line. During the fall of last year, leaves from trees near the plant blew into the clarifiers and settled to the bottom, and in passing through the sludge line became lodged against the end of the drop pipe.

The accumulation was sufficient to practically shut off the flow of sludge. This condition was remedied by taking the drop pipe out of the sludge line and applying the air to the elbow on the sludge line where it changes from a horizontal to a vertical position. The present arrangement gives an unobstructed flow of sludge through the entire length of the sludge-return line.

The growth of leptomitus, which began breaking loose from the sewer system in November, was always present in the aeration tanks in more or less large quantities until April of this year, when it became less prevalent. As far as could be determined the growth had no material effect on the activated sludge or the quality of effluent produced.

Foaming—On one occasion foam developed on the surface of the aeration tanks to such an extent that it overflowed the walls, and at other times it built up to practically the tops of the tanks. This was generally attributed to oil, but there was not at any time sufficient physical evidences to decide definitely that oil was the cause of foaming. The assumption that the foaming was due to oil or oil products seems to be justified because there was no deterioration of the effluent from the plant, and no upset in the normal operation of the aeration and final settling tanks.

There are two final sedimentation tanks, each 28 ft. square, with no. 1 tank 11 ft. deep and no. 2 tank 10 ft. deep. Each tank is equipped with a Dorr clarifier mechanism, and the corners of the tanks are filled in to give a circular bottom. The influent of each of the clarifiers passes over seven 90-deg. V-notch weirs, and the effluent flows over knife-edge weirs. Both inlet and outlet weir plates are adjustable. Each tank has a baffle 4 ft. from the inlet weirs and 5½ ft. deep, consisting of sheets of galvanized iron suspended from I-beams carried on brackets set on the walls of the tanks. The baffles are hung on wires and adjustments for depth and position can be easily made.

Originally, baffles 3 ft. deep and 2 ft. away from the inlet and outlet weirs were placed in the clarifiers. This arrangement, however,

was not satisfactory and the baffles near the outlet were removed and those previously referred to were placed in front of the inlet weirs.

The clarifiers are operated in series, and liquid chlorine is applied to the effluent of no. 1 tank as the sewage flows through the connecting channel. The chlorine is thoroughly mixed with the effluent in the channel and evenly distributed over the weirs on the inlet side of clarifier no. 2.

The sludge in clarifier no. 1 is returned by an air lift to the aeration tanks, whereas all of the sludge from no. 2 tank is discharged by an air lift into the influent to the pre-settling tank. The excess activated sludge from no. 1 clarifier is drawn off by gravity to the thickening tank at the same time sludge is drawn from the pre-settling to the thickening tank. The level of the sludge layer in clarifier no. 1 is determined by sampling cocks in the west wall, which forms one of the laboratory walls. Sampling cocks were not provided in the second unit, nor have they been found necessary since only a comparatively small amount of sludge is deposited in this tank and the smallest amount of air that will operate the lift removes all the sludge.

Although the clarifiers are now operated in series, they are arranged so that they can be used in parallel or as separate units.

Each clarifier was designed on the basis of 1 sq. ft. of liquid surface for each 1600 g.p.d. of maximum sewage flow, not including the sludge returned to the aeration tanks. Although the sewage is pumped into the system at the maximum rate for which the plant is designed, the time between pumping, the long length of sewer line on a flat grade, and the flow of sewage through the plant tend to reduce the maximum rate to a large extent.

But few difficulties have been experienced in operating the clarifiers. Bulking has occurred occasionally, but it has never been serious. By frequently checking the elevation of the sludge blanket in clarifier no. 1, it has been possible to keep the sludge down in this tank to within 2 ft. of the bottom.

Table 1 gives monthly averages of chemical analyses of samples collected from the effluents of the two clarifiers, together with analyses of the raw and settled sewage. The pH of the final effluent is practically 0.22 less than the average for the effluent of the aeration tanks and 0.3 less than the raw sewage. Lowering of the pH, however, is due to the chlorine added to the influent. The results show a high degree of oxidation and a very low oxygen demand. The relative stability of all samples from the effluents of clarifiers no. 1 and 2, incubated at room temperature, has always been 99 plus.

Laboratory facilities have not been available until recently for determining suspended matter. The few results obtained show that the effluent of the second clarifier had 9.2 p.p.m. and the raw sewage 72 p.p.m. suspended matter. The treatment plant as a whole is therefore, at the present time, removing about 87.2% of the suspended matter in the raw sewage.

Disinfection—Liquid chlorine is applied in solution to the effluent of clarifier no. 1 by a Wallace & Tiernan full-automatic unit located

in a separate room on the floor above the laboratory. The chlorine cylinders are on scales in a corner of the laboratory, and the float-control mechanism is in a separate section of the weir box under the floor of the laboratory at an easily accessible place. In addition to the full automatic, solution-feed chlorinator, there is an auxiliary solution-feed machine for emergencies.

Only minor troubles, such as working out the exact size of floats in the weir chamber, have been experienced in operating the chlorinator. The float now in use regulates the flow of chlorine directly in proportion to the amount of effluent flowing over the weir for all heads except 1 in. For heads less than 1 in. a uniform dose of chlorine is applied. The amount of chlorine applied to give a residual varying from 0.2 to 1.0 p.p.m. is 5 p.p.m. at the present time. There are no by-passes at the treatment plant whereby any raw or untreated sewage can be discharged to the river without disinfection.

Sludge Thickening Tank—Sludge is drawn from the pre-settling tank and clarifier no. 1 by gravity to the thickening tank, and allowed to settle for about 3 hours. When necessary, lime is added to the incoming sludge. After settling, the sewage is drawn off through drain lines in the wall of the tank, and the concentrated sludge pumped to the digestion tanks. By discharging the raw sludge and activated sludge together into this tank, it has been possible to reduce the moisture of the sludge far below what could be obtained by discharging sludge from the pre-settling tank and clarifier directly to the digestion tanks.

Digestion Tanks—There are four covered sludge digestion tanks with a combined storage capacity of 1½ cu. ft. per capita for 12,000 maximum daily summer population. Three of the tanks have drain lines in the machinery room for draining sewage from the sludge. The tanks have concrete gas domes and coils for heating sludge. In the machinery room adjoining the tanks, there is a pump for circulating sludge from the bottom to the top of the tanks. Hot water was first pumped through the heating coils early in December, but the heating equipment has not been adequate to maintain an average temperature of more than 60°F. since that date.

Raw sludge was first added to tank no. 1 early in September. Since that time sludge has been pumped every other day. During the early stages of digestion it was necessary to add lime to maintain an optimum alkalinity. The average monthly pH and temperature of the sludge in the digestion tanks is given in Table 1. At the present time, two of the digestion tanks are half full of sludge and sewage. Sewage is maintained in the tanks to prevent leakage of gas through the walls, particularly those separating the tank from the machinery room. Enough liquor is drained daily from the two tanks in use to accommodate the raw sludge added.

On May 7 about 275 cu. ft. of sludge was drawn to the drying beds. This sludge was black in color, had a gaseous odor, and contained 98% moisture.

Gas production developed about 2 months after the first sludge

was pumped into the digestion tanks and there has since been a continuous flow, although the volume has not been great at any time. At present gas is allowed to escape from an open pipe 50 ft. away from the plant.

Bacteriological Analyses—Samples of water from Merced river and other places in Yosemite park have been forwarded to the Federal Laboratory for several years for analysis. The schedule previous to September 1931 for taking samples from Merced river was continued, with the addition of a sampling point 1 mi. below the treatment plant and three samples collected at 8:30, 10:00, and 11:30 a.m. every Saturday from the treatment plant. This schedule included one set of samples per week, and will be continued until a laboratory at the treatment plant is equipped.

In Table 2 are given the number of 10-c.c. portions of individual samples analyzed, together with the percent of samples positive for B.coli. These analyses show that 66% of the 10-c.c. portions of samples collected 2 mi. above the plant were positive for B.coli; 68% below the treatment plant; and 57% at the park boundary. The analyses of samples taken from the effluent of the plant show that 15% of the 10-c.c. portions were positive for B.coli.

These analyses indicate that river water below the treatment plant continued 2% more positive tests for B.coli than the samples collected above the plant; whereas B.coli in the river at the park boundary were less by 9% than for results above the plant. The percent positive tests for B.coli in samples of the effluent appear to be very satisfactory and, as far as weekly samples are representative, the treatment plant has produced a well disinfected effluent. Since tests are made for free chlorine in the final effluent every 2 hours, except between 3 and 8 a.m., and further, since an excess of more than 0.2 p.p.m. has been carried in sewage remaining in the second clarifier more than an hour during maximum flow, it would appear that the weekly bacteriological analyses represent the extent of disinfection of the effluent.

Conclusions—The treatment plant has been in operation 9 months and during this time has practically fulfilled the requirements laid down before its design regarding odors, visibility of plant from highways and the north and south rims, noise, and contamination of the river.

Acknowledgments—I wish to express my appreciation for assistance and cooperation given by my co-worker at the treatment plant, C. R. Willette; E. M. Hilton, park engineer; H. S. Shilko, assistant engineer; H. B. Hommon and O. C. Hopkins, sanitary engineers, U. S. Public Health Service, and E. A. Reinke, of the California State Board of Health, in the preparation of this paper.

(For Tables 1 and 2, see p. 24.—Editor.)

TABLE I

MONTHLY SUMMARY, ANALYTICAL DATA, ACTIVATED SLUDGE PLANT, YOSEMITE NATIONAL PARK

(December, 1931, to April, 1932, inclusive)

Month	Aeration Tanks 3 Times Daily		Digestion Tanks Daily		Effluent No. 1 Clarifier Weekly—p.p.m.		% Settleable Solids—Weekly		
	% Ret. Sludge	pH	Temp., °F.	pH	N. (Nitrites)	Alkalin.	Raw	Sett.	Final
December	27.4	.....	62.1	7.4	0.3	28.8	.....	.....	....
January	33.2	.....	56.3	7.0	.....	26.8	1.3	0.66	Tr.
February	22.0	6.8	53.5	7.35	0.41	46.5	1.0	0.8	Tr.
March	19.7	6.6	61.8	7.65	0.04	20.5	4.0	0.75	Tr.
April	20.1	6.5	65.0	7.5	0.232	17.1	3.5	1.5	Tr.
Average	24.5	6.63	59.7	7.38	0.245	29.96	2.45	0.80	Tr.

Month	Diss. Oxy. Daily—p.p.m.		B.O.D. (5 days) Daily—p.p.m.		pH Daily		% R. Stab. 20 Days at 20° C. —Daily	
	Effluent 1st Clar.	Final Effluent	Effluent 1st Clar.	Final Effl.	Raw Sewage	Final Effl.	First Clar.	Final Effl.
December	.....	8.55	.....	1.33	.....	6.5	.....	99+
January	.....	8.1	.....	0.6	.....	6.3	.....	99+
February	.....	8.5	.....	1.0	6.8	6.5	.....	99+
March	7.6	.....	4.9	.....	6.7	6.5	99+	.....
April	7.83	9.11	2.77	0.95	6.65	6.25	99+	.....
Average	7.71	8.56	3.93	0.97	6.71	6.41	99+	99+

TABLE 2

SUMMARY OF B. COLI IN SAMPLES COLLECTED FROM EFFLUENT OF TREATMENT PLANT AND FROM MERCED RIVER ABOVE AND BELOW PLANT

Source	Period covered	Total no. 10-c.c. portions analyzed	Per cent of 10-c.c. portions positive for B.coli
Effluent of treatment plant	Sept. 1931 to May 1932	460	15
Merced river, 2 mi. above treatment plant	Sept. 1931 to May 1932	190	66
Merced river, 1 mi. below treatment plant	Sept. 1931 to May 1932	250	68
Merced river, at park boundary, 8 mi. below treatment plant	Sept. 1931 to May 1932	230	57

CITY OF LODI ACTIVATED SLUDGE PLANT

By FRED W. POST*

The Lodi activated sludge plant has been in continuous operation since 1923. We have had no serious trouble outside of handling cannery waste. This was discontinued 4 years ago, the cannery being shut down since that time.

The roof and sides of our screen house have been demolished due to the hydrogen sulphide set loose by rotation of the fine screen. The building material was metal. The joints were eaten so badly that we razed the building and will get along with only a housing over the motors. We have put a metal railing where the walls stood and it looks much better than the dilapidated building. Another pleasing thing about it is that the sewer gas and odors are not nearly as bad.

We found the filtros plates at the inlet end of the aerating channels, which have been in use since the plant was built 8 years ago, gradually choking up so that insufficient air appeared in the sewage. Upon dewatering, about 25 cu. yd. of sediment was found between the ridges and furrows over the plates. To get the sediment out we used a small windlass with no extra expense to the city, the operators doing the work. Sediment consisted mostly of sand and water-logged matches and had comparatively no odor.

Our sewers are sanitary sewers, laid on flat grades, but in stormy weather the flow about doubles. It is possible that the sand came from different sources. The city water supply comes from wells, which produce a certain amount of sand. We get a certain amount of storm water from building roofs, alleys, and streets, so are bound to get some sand from those sources. It is also possible to get some from leaky joints along the sewer line. This goes to show that settlers or detritus tanks would be a good thing, even if the sewer carries supposedly sanitary sewage.

The reaerating channels have been in continued use. Some of the plates are complete closed and others are partly closed. We have to raise the air pressure 4 lb. to be able to operate. At the present time, we are changing 110 plates in one reaerator. The cost for labor, taking the old ones out and replacing with new ones, is $1.50 each. We expect to spend about $1500 for plate changing, which is $200 a year for a plant serving 7500 people.

We contracted the sludge output to a Japanese from Oakland. His contract was to keep the drying beds clear of all dry sludge and he put up a building and machinery for grinding. Then, because he could not sell the fertilizer, he fell down on the contract, and the beds got full of sludge. This shows the way such contracts depend on market conditions.

* Superintendent, Lodi Sewage Treatment Plant.

PASADENA ACTIVATED SLUDGE PLANT

By A. W. WYMAN*

Almost every subject having to do with the Pasadena plant has been fairly well covered by papers in the past, except possibly our storage or equalizing tank. Every sewage plant is at some time or other perplexed with the operating problems of extreme difference in rates of flow over 24 hours. Our plant may have a more pronounced problem in this respect, due to the three sources of supply which vary in distances from the plant 2 to 8 mi. An old Spanish custom and laundry routine make these peaks fairly constant from 6 or 8 hours duration; also the familiar Saturday-night peak which is not troublesome.

Nearly any plant will function best with a uniform flow, and this is especially true of an activated-sludge plant. We used to think that during low flows the bacteria strength could be built up to care for these peaks, but this is very limited. For our problem it seemed best to build a storage tank large enough to by-pass any amount over the average flow, and return this to the plant as the flow began to taper off. Such a tank was constructed of redwood staves with concrete bottom. This tank is 130 ft. in diameter and 17 ft. deep. Its capacity, leaving a 2-ft. freeboard, is 1.5 m.g. and I believe this is the largest wood-stave tank in the country.

To eliminate settling of solids, a stirring device was placed in the bottom and revolved by a pump circulating the sewage through nozzles. During cold weather this worked very well, but in the summer months the sewage became quite septic. Although peak rates of 15 m.g. were ironed out, sewage returned to the plant was more difficult to treat than the original raw sewage. Odors became very bad, and one or two buildings near the tank turned from a cream color to a dirty blue, caused by hydrogen sulphide. A non-metallic base paint overcame this difficulty.

To control the odors, instead of circulating sewage, compressed air was substituted through perforated pipes laid in squares 5 ft. on centers, with perforations 1 ft. apart. Aeration of raw sewage alone has very little benefit, as this is for a period of 10 or 12 hours, which is about the time it is held in the tank. However, by adding activated sludge in varying quantities and making a regular aeration unit out of this tank, we have obtained very satisfactory results. Of course, a plant extension large enough to care for peak flows would be much better than this arrangement, but to have added our type of construction to do this would have been much more expensive.

The present capacity of our plant is about 10 m.g.d., allowing a 4-hour detention period. Therefore, with a 9-m.g.d. average flow controlled by this storage tank during peaks, we still have a little reserve capacity for future use or emergencies.

With the last few years of many interesting and troublesome oper-

* Superintendent, Pasadena Sewage Treatment Plant.

ating problems, I believe the control of peak flows such as we have to contend with by the use of this storage tank, deserves a place among other special features responsible for successful operation of an activated sludge plant.

SALINAS ACTIVATED SLUDGE PLANT

Sludge Control, with Particular Reference to Causes and Control of Bulking

By T. R. HASELTINE*

One of the most common difficulties encountered in the operation of activated sludge plants is the bulking of sludge. The plant will apparently function satisfactorily for a considerable period of time and then the sludge bulks suddenly, the effluent deteriorates, and the entire plant becomes disorganized. This difficulty constitutes more of a problem at some plants than at others and has been particularly bothersome at Salinas.

Because of the sudden manifestation of the difficulty, it appears logical to attribute it to discharge into the system of some ingredient not normally present in the sewage. Such is undoubtedly the case at many plants that receive industrial wastes. But, at Salinas all known sources of large volumes of trade wastes are sewered by a separate system that is not tributary to the plant. It was thought at first that our difficulty might be due to the surreptitious discharge of wastes from illegitimate liquor manufacturing, but inasmuch as the pH of the sewage has always ranged from 7.0 to 7.5 and daily tests over a period of several months failed to show the presence of dextrose in the sewage, this belief has now been abandoned.

The Salinas sewage is very strong, but this is due primarily to the low per capita flow. The 5-day b.o.d. is about 0.25 lb. per capita per day, which—while above the average—is not sufficiently high to indicate the presence of any large volume of organic trade wastes. The most unusual characteristic of the sewage is its high grease content. This is believed to be partially due to a large soap consumption occasioned by hardness of the water supply. The high grease content, which is not subject to much seasonal variation, is augmented by frequent discharges of kerosene and lubricating oil. From the beginning it has been noticed that these discharges were frequently, but not always, followed by severe bulking of the sludge.

According to Martin,[1] Fowler states that "it is possible for a certain period of time to obtain quite a good effluent with an air supply about half the amount that experience has found necessary. It has been found, however, that in the course of time, under such conditions, banks of unoxidized sludge form, the quality of the effluent

* Chief Operator, Salinas Sewage Treatment Plant.

deteriorates rather suddenly, bulking of the sludge takes place, and the whole process is disorganized".

Therefore, it appears that the periodical and sudden bulking of sludge at Salinas was due primarily to gradual diminution in the quality of the sludge, probably caused by continued underaeration rather than sudden changes in the character of the sewage, although frequent discharges of oil made the problem more aggravating. This indicates the need of simple, rapid tests to determine the quality of the sludge. After extended experimentation it is believed that we have developed such tests applicable to Salinas conditions and, judging from the underlying principles of the activated sludge process, these tests may be applicable to other plants as well.

The common sludge tests used at most activated sludge plants consist of either or both volumetric and gravimetric determinations of the quantity of suspended solids in the aeration-tank liquor. Taken alone, neither of these tests gives much idea of the quality of the sludge. The quotient of the amount of sludge by weight, divided by the amount of sludge by volume, gives a true indication of the settling quality of the sludge and is much more valuable than either of the two tests alone. This quotient has been variously called the sludge ratio, index, or density, of which terms I prefer the latter. While this determination is of some value, I have found that at Salinas the density will remain fairly constant for several days and then drop or rise quite rapidly. Once it has started on a sudden decline, it is almost impossible to prevent the density from going below the minimum at which the plant will operate satisfactorily.

In order to develop indicators of sludge quality it is necessary to have some idea of the mode of action of the activated sludge. One commonly-accepted theory is that the surfaces of the floc adsorb the finely divided suspended matter colloids and some of the dissolved matter in the sewage, and that much of the adsorbed matter is then liquefied and/or gasified by biological oxidation. Without this oxidation the floc surfaces become so glutted that they can adsorb no additional material. It would appear that the quality and characteristics of the sludge would be dependent upon the balance between adsorption and biological oxidation within the sludge, and that tests indicating the relative progress of either of these processes would give the operator an idea of the quality of the sludge.

Of the three classes of solids in sewage—dissolved, suspended and colloidal—we have ready means for determining only the first two. It is believed that many of the colloids pass through the ordinary gooch crucible or rapid-filtering filter paper, and so are reported as dissolved solids. If this is the case, a comparison of the quality of dissolved matter in the mixed liquor with that in the incoming sewage should give some idea of the balance between adsorption and liquefaction by biological oxidation. If there is less dissolved matter in the mixed liquor than in the sewage, adsorption is progressing faster than liquefaction, and vice versa.

At Salinas it has been found that the amount of dissolved solids

in the sewage was fairly constant at 1000 to 1200 p.p.m., while those in the mixed liquor have ranged from 600 to 1500 p.p.m. It has also been observed that when the dissolved solids in the mixed liquor remained materially below those in the sewage for several days, the sludge ultimately bulked severely. However, if they remained materially higher than those in the sewage the clarification was slightly impaired although a very stable, highly nitrified effluent was produced. The best all-around results were obtained when the amounts of dissolved matter in the mixed liquor and in the sewage were about equal.

It also appears logical that variations in the ash content of the activated sludge might serve as a measure of the adsorption oxidation balance; an increase in ash content indicating an increase in oxidation over adsorption, and vice versa. At Salinas it has been found that about 90% of the time a drop in the ash content was either accompanied or followed by a drop in the sludge density. A rise in the ash content was accompanied or followed by either a rise in sludge density or a marked retardation of the decrease in density, although the actual ash content appeared to have no bearing upon the plant performance. Harris, Cockburn, and Anderson[2] have made similar observations at Shieldhall, England. However, the variations in sludge density were not directly proportional to the variations in ash content. For example, the ash content might decline a uniform amount each day for 5 days, while during the first 4 days the density decreased only slightly, and then dropped very suddenly on the fifth day. A similar relationship was observed with a rising ash content. It is apparent, therefore, that daily variations in the ash content of the sludge give a better idea of the reactions taking place within the sludge than does the determination of its density, and hence serves as a valuable indication of the quality of the sludge.

Since, as previously stated, biological oxidation may result in gasification as well as liquefaction of the material adsorbed by the floc surfaces, it was thought that the time that elapsed before the sludge rose to the surface in quiescent samples of mixed liquor might prove significant. At Salinas we have found this time to range from 30 minutes to 24 hours. There appears to be no correlation between this time and the sludge density. However, periods of active gasification were always preceded or accompanied by increases in ammonia reduction, nitrification, and relative stabilities. I believe a similar relationship has been observed at Pasadena.

Observations indicate that the time that the sludge stays down is dependent not only upon whether it is over or under-aerated, but also upon the amount of adsorbed matter on the floc surfaces, the temperature of the mixed liquor in the aerators, the temperature of the samples while standing, and the size and shape of the vessel in which the samples are collected. Because of these various factors and of the rapid changes which it undergoes when the sludge is on the border line, the exact time that the sludge stays down is of little value as an indicator of sludge condition. But, when reasonable care is taken to control the other variables, the fact that the sludge will rise

in a few hours assures the production of a well nitrified, stable effluent; if it rises very quickly the sludge is probably over-aerated.

However, if the sludge does not rise within 5 to 6 hours, it may be only slightly or very seriously under-aerated. This test is not believed to be as valuable as is either the dissolved solids or the ash determination in controlling the sludge; its chief merit lies in the fact that it requires no equipment other than a glass jar and a watch.

It remains to be shown whether or not these tests will prove of universal application. It is quite probable that even if such should be the case there are many plants treating dilute domestic sewages that would not find them of sufficient value to include in their daily routine. The record of the past year at Salinas shows that serious bulking of the sludge has occurred only after extended periods in which gasification and dissolved solids in the mixed liquor and dissolved oxygen in the effluent were low, and during which the ash content of the sludge continually decreased. Recent results have proved that by so regulating the amount of air used the dissolved solids in the mixed liquor are maintained equal to—or only slightly higher—than those in the sewage, and the ash content of the return sludge, as determined daily at a given hour, is not subject to a continuous decline, all serious bulking can be avoided. When additional air is used, the dissolved solids in the mixed liquor greatly exceed those in the sewage, the ash content of the sludge increases, as does the sludge density, gasification becomes very pronounced, and both the nitrate and the suspended-solid content of the effluent increase.

Our records show that there is always a rise in the volatile content of the sludge following the receipt of oil discharges, but that unless the ash content of the sludge had already been falling for some time before the oil was received, serious bulking did not occur. Apparently the oil either increased adsorption or decreased oxidation, and so it has been found desirable to speed up oxidation by increasing the amount of air used for a few hours immediately after the oil was received. If all fats have the same effect on the sludge, then the fat or grease content of the sewage being treated may have nearly as much bearing upon the air requirements of the activated sludge process as does the b.o.d. of the sewage.

[1] A. J. Martin, 'The Activated Sludge Process'.
[2] F. W. Harris, T. Cockburn, and T. Anderson, 'Biological and Physical Properties of Activated Sludge,' Water Works, Vol. 66, p. 24 (January 1927).

The first concerted effort toward large-scale cleansing of an intrastate western river from gross pollution by domestic and industrial wastes has just been started. Julius L. Meier, governor of Oregon, assisted by civic leaders and prominent sanitary engineers of Portland and supported by his State Board of Health, is planning an $11,000,000 state-wide sewer program, the principal units of which are for primary treatment of sewage entering the Willamette river. Sewage treatment is proposed for Portland, Oregon City, Newberg, Salem, Albany, Corvallis, Eugene, Springfield, Cottage Grove, McMinnville, Silverton, The Dalles, Monmouth, Independence, Lebanon, Woodburn, and other communities in the Willamette basin and elsewhere.

LOS ANGELES COUNTY SANITATION DISTRICTS' ACTIVATED SLUDGE PLANT

By A. P. BANTA*

Larger treatment plants are the Mecca of budding inventive genius. Scarce a week goes by but that some gentleman or salesman arrives with a new panacea of sewage treatment. Sometimes it is the addition of tons of newspaper, or some patented chemical, or some mysterious settling media, or perhaps it is the simpler matter of just distilling the sewage. Paint and building material exponents are legion. Wonder-last-forever metals are nearly as common, and one must expect to have the lubrication system experted several times a year by all the oil companies. It is indeed an operating problem for the superintendent and operators of a plant to deal courteously and fairly with these people and still find time to attend to the plant. Idly curious visitors and those really seeking for information are another test of resourcefulness and tact. I once spent half an hour showing and explaining the plant to a middle-aged man and was apparently getting along fine. As he was leaving he asked, "What do you use for heat to make your tanks boil!"

The qualifications which make for the perfect superintendent or operator of an activated sludge plant are many. He should be intelligent and able to adjust himself to unforeseen contingencies, and yet he must be capable of executing orders faithfully. He must know electricity, wiring, the rudiments of chemistry, bacteriology, machinery, lubrication. In addition, it is well that he has a pleasing personality and conversational ability so that he will make a favorable impression on visitors. In other words, the perfect operator is a rare bird.

The activated sludge plant of the Los Angeles County Sanitation Districts has been in operation over 4 years. This plant is treating a flow of about 13 m.g.d. It is the purpose of this paper to touch upon several of the operating problems which have arisen.

At the districts' plant, a strict policy has been set down in regard to cuts and minor injuries. Employees are required to report to the plant office for first-aid treatment, if even so much as a scratch is received during working hours. New men on the work tend to be careless in this regard and several stubborn infections have developed. Men who have worked around the plant for several years appear to be less susceptible to infection; however, they are as a rule, more careful. There has been only one case among the regular plant employees which has required the attention of a doctor. This case developed from a bruise and infection did not show up until the case had gone to the doctor. Ample first-aid equipment should be supplied at all treatment plants, however small.

There are several other practices which have proven worthwhile from the standpoint of health. All operators are required to change

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clothes before leaving the plant. Ample towel and shower equipment, with hot water, are provided. The record of lost time and injuries shows that plant operation is not a hazardous or unhealthy occupation, at least if correct facilities are provided. Most of the men at the plant have been employed continuously since operation was commenced and take an active interest in the work.

Until about 2 months ago none of the operators have slipped or fallen into the tanks, then in a period of 2 weeks two men fell in, one into an aeration tank and one into a clarifier. The aeration tanks are of the spiral-flow type, and great difficulty was experienced in effecting a rescue. The man who fell in is a good swimmer, and yet he complained of not being able to keep to the surface. When it is considered that the mixed liquor in the aeration tanks is surcharged with finely divided air bubbles, so that the resultant specific gravity is less than one, an explanation of the decreased buoyancy makes the initiation into the Order of the Hell Divers more hazardous than first appears. In this same connection, it is well to point out a similar hazard in connection with open digestion tanks. At one time such open tanks were operated at the districts' plant and it was found that the buoyancy level was often as much as several feet below the apparent surface, the intervening depth being scum or foam. A slip into such a tank would in all probability be fatal.

About a year ago a sludge digestion unit was placed in operation. One of the design features is temperature control by means of a hot-water system, utilizing sludge gas for heat. This system, after a few minor adjustments made after the shake down trial, functioned beautifully. However, it was noticed that, after 6 months operation, the temperature of the circulating water was averaging progressively lower. Several additional burners were hooked up, but the results were disappointing. The boiler was finally taken out of service for a thorough inspection. The boiler is of the vertical fire-tube type; that is, the water surrounds the 90-odd 2-in. boiler tubes, with the heat passing up through the tubes. Inspection showed that the tubes were caked on the outside with a combination of soot and a hard, grey, crystaline substance. In some cases, the tubes were completely closed. The crystaline substance was tentatively classified as sulphate. It was necessary to use a bar and sledge hammer to remove this material. After the cleaning operation, the boiler was returned to service and has worked perfectly. The boiler is now cleaned every 2 or 3 months and no further crystaline material has been found in the tubes.

The question of paints about a treatment plant is a difficult one. At the districts' plant, the solution has not been the selection of a single type of paint which will stand up under all conditions, but rather the use of about six different types of paint. The three principal ones are hull black, aluminum paint, and a bituminous base. For piping exposed to moisture and sunlight, the hull black is superior; it maintains its luster and lasts well. Bituminous-base paints under

(Continued on page 82)

GRAND CANYON ACTIVATED SLUDGE PLANT

By HILLIARD HALL*

The activated-sludge sewage treatment plant† at Grand canyon was designed to reclaim sewage for industrial purposes and has been in operation 6 years. Since I have been asked to discuss special features and operating problems at activated-sludge sewage treatment plants, there will be considered in this paper only the unusual problems connected with operation of the Grand Canyon plant.

Temperature of Raw Sewage, and Laundry Wastes—The temperature of the raw sewage has been influenced to a marked degree by the laundry wastes which are discharged into the sewer system to the extent of about 10% of the strictly domestic sewage. The average volume of these wastes during the summer season is around 12,000 g.p.d., and during the winter, 8000 g.p.d. The temperature of the wastes as discharged from the laundry, is 150° F. The maximum temperature of the sewage upon arrival at the treatment plant during the summer is 92°, while the minimum winter temperature is 72°, and the average for the year 80° F.

Although it has not been definitely proven, the higher temperature of the sewage apparently tends towards improvement of plant operation in winter, but requires more air for sewage aeration during the summer season. It has been observed that whenever the temperature of the sewage is above 85° F., more air is required than at any other time of the year. The higher temperature has lessened the danger of pipes and valves freezing during the winter.

No troubles whatever have been experienced in treating laundry wastes along with the domestic sewage, except the temperature as noted. The washing compounds in the laundry wastes convert the non-carbonate hardness of the sewage to sodium carbonate, which does not produce scale in boilers or jackets of deisel engines using the reclaimed sewage. Since a large proportion of the reclaimed sewage is used for generating steam and cooling water for the jackets of deisel engines, the benefits resulting from the laundry wastes in the sewage outweigh the disadvantages of an apparent excess of air required for the aeration tanks at certain seasons of the year.

Aeration Tanks and Clarifier—The two aeration tanks have been operated continuously in series, practically ever since the plant was placed in operation, and no unusual difficulties have been experienced except on one occasion when oil entering the treatment devices caused so much foaming that it was necessary to waste all of the sewage in the plant except activated sludge which did not absorb the oil and could be settled and retained.

The clarifier has been in continuous operation for the entire 6 years, and no repairs have been required in that time, except replace-

* Operator, Sewage Treatment Plant, Grand Canyon National Park.
† For description of plant see Reprint no. 1249, Public Health Reports, October 5, 1928, Government Printing Office, Washington, D. C.

ment of the rollers which support the revolving arms. It is believed, however, that the scrapers are practically worn out and will, in the near future, have to be replaced.

There are two gravity sand filters containing 30 in. of sand. There were placed, originally, in filters no. 1 and 2, respectively, sands with effective sizes of 0.35 and 0.40 m.m., and uniformity coefficients of 1.6. The finer particles of the sand in both filters have been washed out and the effective size at the present time is around 0.45 m.m.

Since the original installation included sufficient sand-filter area to treat a maximum of 200,000 g.p.d. of sewage, there is ample area to filter the effluent from the clarifier without addition of coagulents. The filters operate at a net rate of 28 m.g.d. per acre.

During the first few years the filters were washed whenever the total loss of head was 10 ft. Under this method of operation, mud balls developed on the surface and in the filter sand, and there was an accumulation of organic matter that could not be washed out with a reasonable amount of water. The net result was a lower quality of effluent. At the present time, the filters are washed every 24 hours when the flow of sewage exceeds 100,000 g.p.d. and every 48 hours when the volume is less than this figure. The amount of wash water used has varied from 1½% to 7%, with an average of 3½%. The wash water is collected in a concrete reservoir and returned with all the suspended matter to the inlet of the pre-settling tank.

Disinfection of Effluent—There are two semi-automatic Wallace & Tiernan liquid chlorinators, used for applying chlorine to the effluent of the gravity filters. The chlorine requirement has averaged 5 p.p.m., with an excess of 0.6 p.p.m. in the reclaimed sewage pumped to the storage reservoir. The amount of chlorine in the distribution system has varied from zero to 0.5 p.p.m., but the chlorine has had no appreciable effect on lawns or flowers and vegetables irrigated with the reclaimed sewage.

During the past 2 years the overflow from the chlorinators, which operate intermittently, has been discharged into the influent to the gravity filters. The chlorine in the influent has practically removed all traces of mud balls in the filter, and the quality of the effluent has been improved. Chlorine is, however, applied continuously to the suction of the pumps in the clear well, when the pumps are in operation. Tests for free chlorine are made each time the pump operates, except between 12 midnight and 7 a. m., when there is no operator at the plant.

Bacteriological Analyses—Since tests have shown excess chlorine in the filter effluent when the pumps are in operation, bacteriological analyses are made only of samples collected from the storage reservoir and the make-up tank in the power-house. Sixty-nine samples of reclaimed sewage were collected from the storage tank in 1931 and tested for B. coli, and 61 from the make-up tank. Five and one-half per cent of the 345 portions (10-c.c.) examined were positive for B. coli in the samples from the storage tank, and 6½% of the 305 portions from the make-up tank.

In addition to bacteriological analyses of samples of reclaimed sewage, a large number of chemical and bacteriological analyses are made of samples of domestic water used in the area having the dual water supply systems. The purpose of the chemical analyses is to determine whether the domestic water supply system has been accidentally cross-connected with the reclaimed sewage lines.

The reclaimed sewage is used for generating steam in locomotive and stationary boilers, cooling deisel engines, irrigation, flushing toilets in comfort stations, and washing automobiles. No unusual difficulties have been experienced in use of reclaimed sewage for these various purposes. The reclaimed sewage pipe-lines are all enclosed in vitrified sewer pipe where the lines are underground, and above the ground the pipes are painted red. Warning signs are placed over all outlets accessible to employees or the public. A map showing both the domestic water supply system and reclaimed water lines is kept up to date and the superintendent of the park approves and checks all extensions of the reclaimed sewage lines.

The sewage is pumped from the clear well at the treatment plant to a 250,000-gal. steel tank, with the bottom at the ground surface. This tank is generally full of water and has never been emptied and cleaned. The water drawn from the tank has no odor, color, or turbidity.

Chemical Analyses—In the following table are given the averages of chemical analyses for 1931. These results show that the final effluent was well oxidized at all times and stable, and that there was only a very small amount of suspended matter pumped to the large storage reservoir.

The average cost per 1000-gal. of sewage reclaimed in 1931 was $0.37. This included, however, only the cost of operation, maintenance, and repairs, and did not cover interest on investment or depreciation. Since the cost of fresh water was about $3.09 per 1000 gal. delivered at the canyon in tank cars, the treatment plant, on the basis of cost of fresh water, yielded $2.75 per day profit for an average of 100,000 gal. of sewage reclaimed daily.

AVERAGES OF CHEMICAL ANALYSES* AND OTHER DATA FOR 1931

Source	Susp. Matter p.p.m.	B.O.D. 5 days room temp. p.p.m.	Dissol. Oxygen p.p.m.	Soap Hard. p.p.m.	Alkalin. as $CaCO_3$ p.p.m.	Rel. Stabil.	Temp. deg. F.
Raw sewage	83			85	246		81
Clarifier effluent	11	4.8			173	90	
Plant effluent	3.0	1.7	5.3	88	165	98 plus	72
Effluent from distribution system at powerhouse		1.4	5.3				

* Averages are for analyses of 52 samples collected at 11 a.m. once a week.

OPERATION OF LOS ANGELES COUNTY SANITATION DISTRICTS SEWER SYSTEM

By FRED D. BOWLUS*

During the past 6 years nearly 150 mi. of trunk-line sewers have been constructed by the eight Los Angeles County Sanitation Districts. These districts serve a large area in Los Angeles county east, south and west of the city of Los Angeles. Trunk sewer diameters range from 10 in. to 10 ft. and 1000 mi. of local lateral sewers have been built and connected to these trunks. The laterals comprise the systems of eighteen incorporated cities, large areas served by county improvement districts, railroad companies, oil companies, and the Los Angeles County Farm.

The cities, county, and private local systems were constructed under different specifications, and naturally varying qualities of workmanship were produced. From the outset the chief engineer of the sanitation districts has insisted that plans for connecting systems be approved by him. Prior to connection to the trunk-line system, all locals have been carefully inspected, giving special attention to admitting a minimum of ground water infiltration and to removal of all sand and obstructions.

The problem of maintenance of such a large system of sewers is considerably involved. Most of the connected cities have their own maintenance crews and the Los Angeles county surveyor's office also maintains 400 mi. of the county improvement lines. Coordinating cleaning of the sanitation districts' sewers with those of the local systems is essential to avoid the latter lines being cleaned just prior to the trunks below.

The sanitation districts sewers have been in operation more than 4 years. Considering that they were built for a large future growth, typical of southern California, and that the flow now averages but 0.1 to 0.2 of capacities, results have been excellent. Maintenance costs have been low.

Besides the strong domestic sewage, hundreds of industries are connected to the system. One factory alone contributes 0.5 m.g.d. Since the sanitation districts sewage is treated by the activated sludge process at a plant near Wilmington, the industrial load has been a matter of intense study and correction during the past year. It was found difficult to obtain reliable information from manufacturers in certain cases, even with detailed inspection of the factories. Each manager contended that all by-products were too valuable to by-pass any into the sewers. The larger factories generally afforded cooperation but it was the small factory struggling for an existence that gave the most trouble.

A comprehensive survey of the entire system of sewers, including

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analyses and observations of the sewage, has made it possible to trace a particular waste to the point of connection of the individual plant. In this work pH values and temperatures were of great importance. Caustics or acids released into the sewer were easily detected, and calculations could be made as to the exact hour of a certain day when the offense was committed. Offending parties found it hard to deny such discharges when confronted with this evidence.

The general sewage survey of the system during the past year has indicated the magnitude of the industrial waste problem and brought out some interesting points to be considered. Certain acid wastes having a deleterious effect on the sewers and others tending to clog or coat the insides of pipes had to be excluded from the sewage system. However, the large quantity of trade wastes are readily disposed of and are comparatively easily handled in a treatment plant if released uniformly during the 24 hours of the day. It is believed that acid or caustic shots, which in a few minutes greatly change the pH value of the entire influent at a treatment plant, are disastrous to the normal bacterial growth. An instance of this will suffice to illustrate the problem. A small soap factory 20 mi. from the treatment plant had been in the habit of occasionally discharging into the sewer a very caustic liquid. As the factory only contributed a few thousand gallons of waste daily, it was hard to convince the manager that he was responsible for changing the pH value of the entire flow at the treatment plant from say 7.5 to 8.5 within half an hour.

The general survey also disclosed that hydrogen-sulphide gas was present in most of the trunk sewers, especially at certain hours of the day. This caused considerable odor nuisance at the treatment plant. Nine chlorination stations have been built and are now in operation to prevent the formation of this gas. In connection with the location and operation of the chlorinators, much information was needed regarding the hourly and daily sewage flow. To allocate the cost of operation of the treatment plant and maintenance of the systems between districts, quarterly measurements of sewage have been made. Many other miscellaneous measurements were taken to check up the actual flow of sewage from certain areas with that anticipated in the original plans for the districts.

The sanitation districts have contracts with the city of Los Angeles to dispose of certain small quantities of sewage through the latter system. Measurements of these lines are also made regularly. All sewage measurements were made by installing rectangular or Cipolletti weirs in the inverts. A float and stage recorder were installed and a week's continuous record obtained in each instance.

It is believed a novel method was used in determining the velocity of flow in long sewer systems and time of concentration by taking advantage of the pH change resulting from shots of acid or caustic introduced in the upper end. The time of arrival of these shots could be detected within a few minutes, even 10 or 15 mi. below the point of original application.

GLENDALE SEWER SYSTEM OPERATION

By J. C. ALBERS*

The total area of the city of Glendale is 19.2 sq. mi., the present sewer system serving practically all except the steep mountain areas. The city is served with a gravity system except for one small area (0.9 sq. mi.) which it is necessary to pump. This portion of the system empties into an underground reinforced concrete pump station, 24 ft. diameter and 23.5 ft. deep. This sewage is lifted 21 ft. into the Los Angeles outfall sewer.

There have already been constructed 226 mi. of sewers and 10,685 house connections. It has not been made compulsory that all houses connect to the sewer. However, no one is allowed to build new cesspools or pump old ones, so that as soon as the old cesspools fill up the property owners must have the connections made to the sewer. No cesspools are allowed on new building construction.

To operate a system of this size requires four men, two men to a crew. All flushers are regularly inspected and repaired. One crew looks after the flushers and the other takes care of cleaning sewers, cutting tree roots, etc. Both crews are supplied with a safety lamp, and in no case is a man supposed to go into a manhole without first testing it for gas.

The Glendale Street Department has jurisdiction over maintenance of the sewer system and provides a 24-hour service through the yard office, where men are on duty for emergencies at all times.

A map of the sewer system, 600 ft. to the inch, showing the size of mains, when laid, direction of flow, location of manholes and flushers, and the type of flusher, is kept up-to-date for the convenience of those in charge of maintenance.

The quantity of sewage is gaged two consecutive days per month, the reading being taken with four Stevens water meters, operated simultaneously. The combined average daily reading has been 4.44 m.g. over the past 12 months, this amount representing 43.2% of the lots where sewers are available.

In constructing a sewerage system in a city with the topography of Glendale, it was necessary to secure numerous easements. This was particularly true in mountainous areas where it was necessary to serve the lots on the low side of the street from easements in the rear. The cost of securing these easements is something to be taken into consideration, especially as some of our southern California real estate is plastered with numerous papers, from all of which releases have to be secured.

To keep a sewer system functioning properly it is necessary to give considerable attention to it, and to impress on those carrying on the maintenance the importance of this work.

* City Engineer of Glendale.

OPERATION OF SACRAMENTO SEWER SYSTEM

By CARL M. HOSKINSON*

The city of Sacramento operates a combined sewer system in sizes ranging through 114, 108, 102, 84, 72, and 60-in., down to 6 in. as a minimum. The size of solids received in the sewer system seems to be only limited by the size of manholes in the drainage lines. Planks of large size, dogs, cats, rats, and assorted smaller debris is received at the sewage pumping station. There is an unusually large number of shade trees in the residence section, and leaves are a constant source of trouble when falling in rainy weather. Screening of sewage is practiced to protect pumps and is accomplished by use of coarse pipe screens built of ½ and ¾-in. pipe, spaced about 2⅜ in. apart, usually operated with two screens in series ahead of each pump. All pumps except two are of the centrifugal type with ports of sufficient size to pass at least 3½ to 4-in. solids.

The principal nuisances arriving at the plants in the sewers are crude oil and cannery wastes, such as spinach, peach, and asparagus trimmings. Oil is usually traced back to its source, and as its introduction into the sewers is prohibited, steps are taken in individual cases to stop such dumping. The dumping of cannery wastes into the sewer is allowed, with the requirement that such wastes, particularly spinach, be cut into fine pieces in ensilage cutters. These solids may then be passed through the pumps and discharged into the Sacramento river in finely divided particles without causing a nuisance.

Screenings amount to about ½ to 1 cu. yd. of wet solids per plant per day. In former years these screenings were removed by hand and hauled to a suitable dumping ground at a cost of about $3.00 per cu. yd., but during the past 3 years all screenings have been buried in pits 4 ft. wide by 30 ft. long by 6 ft. deep, and it has been found that such a pit may be used for 12 to 18 months, due to contraction of screenings by drying and rotting. Screenings are often dug up after a year and used as fertilizer on lawns and flowers. When fresh screenings are dumped, a 1-in. layer of earth is spread over each dumping. This practice has been found effective in eliminating flies and odors which constituted quite a nuisance formerly, as one of the plants is located near a good residence section.

It has been realized for some time that the pumpage of water from the city water works into the mains is excessive during light load, as the rate of such pumpage rarely falls below an 11-m.g.d. rate in winter months and runs 15 m.g.d. during summer months, with this minimum rate occurring about 3 a.m. The water works serves about 24,000 users and the sewer system drains wastage from about 28,000 users, as it also serves a section of the city served by a private water system. The total daily pumpage of sewage rarely falls much below 14 m.g.d., and during summer dry weather usually runs from 14 to

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17 m.g.d., though this rate is not accurately metered, but is arrived at from pump capacities at known heads.

During March of this year tests were made of rates of water and sewage pumpage to check previous records of flow and determine whether previously indicated pumpages actually occurred. The test of water works pumpage was made by pumping the entire supply through one 15 by 30-in. Venturi meter between 9 p.m. and 6 a.m. for four days, and it was found that the minimum pumping rate during the test was 10.8 m.g.d. A similar test was made at one sewage pumping station by pumping all city sewage flow through one 20-in. pump for a period of 8 hours between 1 a.m. and 9 a.m., using suction and discharge gages and the factory characteristic curve of the pump for indicating discharge rate and holding the sewer at uniform level to get the actual flow condition at that time. This test indicated a minimum pumping rate of 12.5 m.g.d. at 5 a.m., and is considered a fairly close check on the water works pumping rate when allowance is made for 4000 or more extra water consumers taking their supply from wells.

With reference to Batty's remarks on difficulties with centrifugal pumps with sewage-type impellers, we wish to record a more pleasing result from the change made in two 20-in. horizontal pumps in one of the city plants. Each of these two pumps may be operated at speeds of 514 and 600 r.p.m. by either of two motors in tandem, and formerly used multiport open impellers with special side plates. When clean, these pumps operated satisfactorily, but became clogged so easily with string, spinach roots, rags, and other trash that their capacities were greatly reduced, and made cleaning through handhole plates necessary at least once and often several times during each 8-hour shift. In December 1931 and January 1932, these multiport runners were removed and a new type of 2-port closed runners was installed. To this date it has not been necessary to open either pump for cleaning, and it has been found possible to discharge about the same amount of sewage with only 74% of the former time of operation.

On January 1 of this year, the water division of the city of Sacramento was set up as a self-supporting utility under a new ordinance, to collect its own revenues and maintain itself as a separate entity in the city administration. The sewage disposal is also under this division, but is supported by direct taxation as before.

The object of this Association shall be the advancement of the fundamental and practical knowledge concerning the nature, collection, treatment and disposal of sewage and industrial wastes, and the design, construction, operation and management of sewage works in California, through the interchange, between members of the association and with others, of information, experience, and opinion relating thereto.

—Article III, Constitution, C.S.W.A.

UNUSUAL OPERATING EXPERIENCES, CITY OF LOS ANGELES

By F. A. BATTY*

Los Angeles has a sewage pumping plant in the southern part of the city. This plant takes care of the sewage from an area some 2 mi. square. The sewers in this area have a maximum depth of 21 ft. and the sewage is pumped through a 10-in. cast-iron force main 2472 ft. (Force main has since been replaced by a 16-in. cement pipe main.)

This plant has been in operation several years and was equipped with two duplicate force pumps having a capacity of 12 g.p.m. each. In the early part of 1930 a contract was let to replace these pumps with two duplicate pumps having a capacity of 2750 g.p.m., as the original pumps had not sufficient capacity to take care of the increased sewage flow. These new pumps developed cavitation, which caused excessive vibration. Packing was maintained with difficulty and bearings gave considerable trouble.

On August 17, 1930, the operator on making his usual visit to the plant, found both pumps out and sewage rapidly rising in the sewage system and pump pit. This date was a Sunday and it was some time before I was notified and sufficient personnel had been gathered to handle the work.

Equipment had to be procured and the work of pulling pumps started. This plant is the wet-well type, the motors being on the ground level of the plant and shafts and pump frames extending 35 ft. down into the wet well to the pumps, which are set 9 ft. above the wet well, with a 9-ft. suction below the bottom of the pumps. The contractor, in endeavoring to lessen the vibration, had anchored the pump frames at the bottom and some difficulty was encountered in loosening this anchorage in 28 ft. depth of sewage.

The situation confronting us was that both pumps were out and 1.6 m.g.d. of sewage was being contributed to the system; there was no prospect of completing the repair of pumps for several days; and the hot August weather accentuated the sewage odors all over the district.

A by-pass had been constructed between the sanitary sewer system and an adjacent storm drain. This allowed the sewage flow to enter the storm drain and thus prevented sewage from flowing over the streets. The storm drain emptied into an open ditch, which flowed into Compton creek. Strong sewage odor and gas developed in this drain, which poured out of every catchbasin, many of which were adjacent to business houses and residences. Considerable odor was also given off from the open ditch, especially at night. Needless to say, vociferous protests were in order.

Chloride of lime, also liquid ammonia, were applied to the effluent

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at various points by human feeders, day and night, which effectively reduced these odors. I went some distance to investigate conditions and found farmers irrigating with the effluent. The treatment was so efficacious that they had no knowledge they were irrigating with sewage and were greatly pleased with the increased quantity of water.

In constructing the by-pass to the storm drain, the depth of basement connection to sewer was unknown or not considered, the by-pass being at a higher elevation than the basements, and considerable damage was done to merchandise stored therein. One of these connections was to the basement of a local moving picture theater, in which all the dressing rooms and property room, etc., were in the basement. On the Monday night and several nights following, this theater put on a Fanchon & Marco show and you can imagine the difficulty of the proprietors in handling the problem of several changes of costume for the dancers, with all dressing rooms flooded with sewage. He was of course very much put out, but he realized that we were doing our best to overcome the situation and finally invited us to come to his theater any time we wanted, gratis.

One pump was replaced and re-installed by August 23, and the other a few days later. These pumps continued to give trouble, and eventually the contractor rebuilt both pumps, increasing the diameter of shafts, etc. Since this was done we have had no more trouble.

I feel that this experience was so unusual that I sincerely hope it will not be repeated.

OPERATION OF OAKLAND SEWER SYSTEM

By T. F. EASTMAN*

The sanitary sewer system of Oakland constitutes somewhat less than fifty independent systems, each with an outlet either in Oakland harbor on the south or San Francisco bay on the west.

Oakland history has been prolific in the number of its public service corporations. At one time there were three distinct water systems operating and paralleling each other, supplying the same locality. We have an energetic gas company which has absorbed several older companies and, in some places, still operates parallel gas mains. Adding to this two or more power companies with duplicate conduit ducts and capacious junction chambers scattered here and there through the streets, you have a pipe layout which makes the construction of new sewers or the operation of existing ones frought with problems which usually may be considered as more unusual than usual!

However, one of the most unusual occurrences that has come to my notice happened during the construction of the railroad fill over the 22nd st. sewer outfall. This occurrence, however, was due to other causes than that of obstructions such as live and dead pipes in

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the streets. This 22nd st. reinforced concrete sewer outfall, 6 ft. wide by 6 ft. 2 in. high, was extended on a pile foundation through the Key Route trestle in 1911 in order to lessen the septic conditions in Key Route basin. About 2 years later the present fill was constructed by the Key Route to replace their trestle. This fill was formed by dumping trainloads of earth and rock from the existing trestle, the work progressing from the shore outward. No variation in this method of dumping was made when the sewer was reached, and here the fill was placed from one side of the sewer without support on the other side. The obvious result occurred. The sewer was pushed from its foundations, or possibly the foundations were removed with it, rotating on the lower end of the piles as a center.

Two electric locomotives were brought to the scene and cables passed around the sewer. Then with the combined tractive haul of the locomotives the sewer was pulled back onto its foundations, or the sewer and foundations were rotated back into place. I trust that the repair of a sewer of this size by coupling it to a doubleheader of locomotives and thereby making a mobilized sewer unit of it, is sufficiently extraordinary anywhere to be considered unusual.

Lest some laymen with political aspirations consider using this method as a means of saving money by mobilizing their sewers instead of building new sewers in the right place, I will say that this sewer has settled about 2 ft. or more at this point.

Whenever inspection is made by boat from the outfall end, great care must be taken to watch the incoming tide, as a slight rise may cause the boat and those in it to be forced by recurring surges against the top at the sunken portion. This is said by those who have experienced it to be quite irritating.

A sad instance in which our field party came afoul of the law is as follows: The west branch of the Glen Echo Creek sewer varies in size from 6 by 5¾ ft. at its open end at a point a little south of 38th st. to 5 ft. circular and then to 4½ ft. circular at Broadway and Whitman st., the whole distance being about 3700 ft.

During the survey of this sewer in 1927, the three field men from our office making the survey found themselves, at night, completely blocked from further progress by a board with a tree behind it wedged tightly across the sewer at the upper end of the section described above. As the walk of about three-quarters of a mile back to the open end did not seem attractive at that late hour, they dropped back about 1000 ft. to a manhole on the main street, but were unable to lift the cover. They then stuck a stick up through the hole in the cover and waggled it in true golf fashion. After years and years, seemingly, an eye appeared at another hole and a voice, with the proper brogue of a good American guardian of the peace, yelled, "What in h— is going on down there, anyway?" After they were each hauled out and looked over from top to toe with a baleful eye and their story duly noted, the guardian of the peace reluctantly left them, muttering as he went, "Well, it may be all right but it looks durn suspicious".

ODOR CONTROL AT THE WHITTIER SEWAGE DISPOSAL WORKS

By ALVA J. SMITH*

The city of Whittier, California, has recently made a number of improvements at its sewage disposal works with the primary object of odor control, and offers a typical instance of one of the recent trends in sewage disposal practice; that of making an existing plant operate in such a manner that it is not objectionable to the residents of the immediate neighborhood.

Historical—The original installation made in 1923, consisted of an Imhoff tank, sprinkling filter, sludge beds, and final settling tank. The growth of the city greatly exceeded expectations, however, and in 1925 a fine screen was installed to reduce the amount of solids which the Imhoff tank was obliged to care for. In 1927 the original installation was duplicated.

Operating results were generally satisfactory as far as the quality of the effluent was concerned, but the rapid development of the property near the plant made the matter of odor control increasingly important. In 1930, complaints were so numerous that action was necessary and, following a carefully conducted odor survey, the recently completed scheme of odor control was worked out.

When the Whittier plant was built 9 years ago, the location was well isolated. At that time there was but one house within 2000 ft. and that was on the 98-ac. farm belonging to the city. Since then the real estate man has been 'Johnny on the job' and three subdivisions have been laid out on land adjoining the sewer farm. There are now more than twenty houses within 2000 ft. and forty within 3000 ft. of the plant; the closest being within 700 ft. Naturally, complaints were frequent and many of them were justified.

Causes of Odors—A study of the problem shows that many obnoxious gases, and volatile diffusions of non-gaseous substances, are given off as a product of the breaking down of organic matter under bacterial action. The main offenders among these substances are hydrogen sulphide (H_2S) and phosphine (FH_3) among the gases, and indol ($C_8 H_7 N$) and skatol (C_9H_9N) among the non-gaseous compounds. All of these products are hydrogen compounds which result from the putrefaction or fermentation of organic matter. Methane gas (CH_4) is one of the principal products of anaerobic decomposition, but while odorous it is not particularly objectionable.

Sources of Odors—The main sources of odors about a sprinkling filter plant such as the one at Whittier, are the screens, sludge-elevating machinery, place of disposal of screenings, Imhoff tanks (which when not properly cared for are an especially fruitful source), sprinklers when in action, and the creek, farm, or spreading ground

* With Black & Veatch, Consulting Engineers, Los Angeles.

where the effluent is discharged. These are all places where odors may be released in considerable amounts, but the truth is that all of the units of such a plant are potential sources of odors, and only by daily care and thorough cleanliness can complaints be avoided unless the plant is unusually well isolated.

Sludge-drying beds often emit strong odors after a rain has fallen on a batch of partly dried and incompletely digested sludge. Certain atmospheric conditions are conducive to diffusion and transportation of gases. At times on murky, foggy days everything about such a plant seems to emit an unpleasant aroma, while on bright, unclouded days little of the kind can be noticed. As hydrogen sulphide and phosphine have a specific gravity only slightly greater than air (1.18+) they are readily carried by ascending air currents to altitudes many hundreds of feet above the ground, only to be brought down again by descending currents, perhaps a mile away from their source. Odors have been known to be carried by reverse currents in the upper air and be dropped down to the ground at considerable distances to the windward side of their point of origin. Such occurrences are not frequent, however. In making study of the odor situation in any particular case the velocity and direction of the prevailing winds are items that should be collected with care, and the results given reasonable weight in formulation of final conclusions.

At Whittier a survey of the plant and grounds revealed the fact that odor foci of greater or less intensity were located at the screen house, Imhoff tanks, piles of scum that had been permitted to remain near the Imhoff tanks, pools of sewage that had leaked from an elevated sewer, sprinkling filters when in action, the creek below the plant where sludge had been allowed to accumulate by a lax operator who failed to draw and dry the settled sludge from the Imhoff tanks, and finally the farm on which excessive amounts of incompletely treated sewage was used for irrigation.

Odor Survey—At the request of the city of Whittier, an odor survey was made to determine the justification for the complaints that had been made regarding the plant, to ascertain by actual observation the conditions prevailing at and about the plant, and to secure first-hand data upon which intelligent design of proposed improvements for odor reduction might be based.

In carrying out this survey a weather vane was installed at the plant and a wind record kept during the 2 weeks of the survey. Sheets of paper were ruled in columns for the purpose of recording dates, time of day, and character and strength of odors observed. The papers were distributed to ten residents of the neighborhood who had agreed to assist in the survey by making a record of their own observations of odors that were presumably coming from the plant. These records, kept with varying degrees of faithfulness, proved to be of considerable value; not so much for the actual information they contained, as for an indication of the psychological effect of the presence of such a plant on intelligent residents of the district.

Many of the odor conditions noted by the residents in their reports were in direct conflict with the observations of their next-door neighbors and did not agree with our own records made at the plant, at the same time of day. A careful checking of the records, however, shows that some were unbiased by their own personal interests and made faithful records of facts.

The Whittier sewage treatment works are located 4 mi. directly south of the business district of the city. The sewage treated is mainly of domestic origin from a population of 15,000; is rather above medium strength; contains only small amounts of trade wastes that tend to impair the treatment processes; and is often stale when it reaches the plant. Heavy doses of oil that are very detrimental to the successful operation of the plant are received at intervals. The presence of this oil has been noticed in the Whittier sewage on numerous occasions in quantities sufficient to seriously interfere with the functions of the Imhoff tanks and sprinkling filters. This oil at times has the odor of crude oil. A sample showed a specific gravity of 0.887 or an equivalent of 28° Baumé, and a flashing point of 220° F. This would indicate an overflow from some oil well, or perhaps a mixture of lubricating oil and gasoline. Among the troublesome sources of odors about the plant, were the pits into which scum and oil taken from the Imhoff tanks were deposited.

Recommendations—After completing a study of the conditions found at the sewage disposal plant, the following recommendations were made and approved by the city council:

1. That the existing Dorr screen be operated continuously, and that the size of the slots be increased to ½ in. in order to reduce the volume of screenings and the amount of offensive matter they contain.
2. That a gas or oil-fired incinerator be installed within the screen house.
3. That a tank for pre-aeration and for oil skimming be constructed.
4. That provision be made for treating the effluent with liquid chlorine.
5. That the plant grounds be leveled off, drained where necessary, and the debris from past construction be removed, or at least piled neatly as an isolated point on the grounds.
6. That a pumping station be constructed to receive the final effluent from both filters, the effluent to be pumped to the farm for irrigation purposes rather than the septic Imhoff tank effluent which has previously been used for that purpose.
7. That in the future, a great deal more care and attention be paid to cleanliness around the plant than has been paid in the past.

The screen house contains the Dorr screen, air blowers, an air-lift sludge pump for handling screenings, and an incinerator for burning the heavy screenings from the bar screen.

New plates were provided for the Dorr screen in which the openings were round holes ½ in. diameter to replace the old plates which were perforated with ⅛-in. slots. This change was made in order to reduce the amount of screenings to be disposed of, and results in a slightly increased load on the settling compartments of the Imhoff tanks. They are well able to carry this, however, due to the improvement in sedimentation caused by pre-aeration of the sewage.

The screenings and scum are removed from the sump back of the screen by a simple air-lift pump which discharges them through a 6-in. cast-iron pipeline to one of the Imhoff tanks for digestion. The screenings from the coarse bar screen, amounting to between 1 and 2 cu. ft. per day, are dropped through a trap door in the screen-house floor to a gas-fired incinerator in the basement, where they are burned without perceptible odor. The quantity of gas required to burn the screenings is rather high, amounting to 400 cu. ft. of gas per cu. ft. of screenings. The air blower is driven by a 5-hp. electric motor, and has a capacity of 115 c.f.m. of air under a pressure of 5 lb. per sq. in. when driven at 750 r.p.m.

Pre-Aeration Tank—The aeration tank, placed between the screen house and the Imhoff tanks, has a length of 40 ft., width of 10 ft., and a water depth of about 8 ft., with a detention period of 28 minutes at the present average flow of 1.25 m.g.d. The purpose of pre-aeration is to furnish a supply of dissolved oxygen to the sewage, to sweep out hydrogen sulphide and other odoriferous gases, to reduce the b.o.d., to aid sedimentation in the Imhoff tanks, and to facilitate removal of grease and oils which are particularly troublesome at this plant.

The aeration tank is of the plain ridge-and-furrow type, having six transverse lines of 12-in. filtros plates set 6 ft. 8 in. center to center. The grease compartment, which is 10 by 10 in plan and 8 ft. deep, is provided with a skimming trough for removal of the scum which forms after aeration. The scum, composed of partly saponified oils and other light matter, is driven by baffled currents to the collecting end of the compartment, where it is removed by a squeegee over the sloping apron of the skimming trough. The skimmings are further dewatered by collection in a grease trap, and after being dried on a concrete drying slab, are burned or buried.

Although the detention period in the new aeration tank is short, it is sufficient to restore, or perceptibly increase, the depleted supply of dissolved oxygen in the sewage. Removal of hydrogen sulphide is satisfactory, sedimentation in the Imhoff tanks is improved, and the labor required for skimming is much reduced. The latter statement is true to such an extent that the plant attendant says that while installation of the new equipment has brought diversity of interests to him, it has not added to his work.

Determinations made in the laboratory of the city of Los Angeles indicate a reduction in b.o.d. of 13.6% while the sewage is passing the aeration tank. Samples taken April 28 show the following b.o.ds.: aerator influent—375 p.p.m., aerator effluent—324 p.p.m., Imhoff tank effluent—129 p.p.m., final effluent—25 p.p.m., d.o. in final effluent—4.2 p.p.m.

Relative stability determinations, made by the methylene-blue test at intervals over a period of some months, are very erratic, ranging from 0 to 2 hours in the influent and 30 minutes to 6 hours in the aerator effluent.

Hydrogen sulphide determinations made by the State Board of Health show 0.75 p.p.m. in the influent and a trace in the effluent from the aerator.

Sprinkling Filters—The effect of pre-aeration on the sprinkling filters is shown by a decided reduction in the amount of odors given off when the sprays are in action, and a slight improvement in clarification of the effluent. (Possibly some increase in dissolved oxygen, with a corresponding reduction in b.o.d., has taken place.) Unfortunately, on account of lack of any record of laboratory tests of the original effluent, these results can not be established by analysis without shutting down the aeration process and allowing the plant to recover its former condition, and then taking samples for analysis. However, a good indication of improved conditions is shown by the action of a school of small fish which had been observed in the creek a half-mile or more below the plant but had never been seen nearer. The fish promptly moved up to the very outlet of the plant after aeration started. Apparently they were satisfied with their habitat and entirely oblivious of the fact that they were not basking in aqua pura.

Pump House—A stucco pump house 18 by 26 ft. in plan, with a concrete pit, was built to provide for electric motors, switches, motor-driven centrifugal pumps to force treated sewage to the farm, and a small centrifugal pump for furnishing water under pressure for hosing down the Imhoff tanks and keeping the plant clean. Space is also provided for the chlorinator that is to be installed later and storage of two 1-ton chlorine containers. A recording water meter for measuring the discharge from the pumps is also located in this house.

The cost of the new improvements will amount to between $15,000 and $16,000 when the present program is completed. The operating costs per million gallons of sewage treated will be increased by the following amounts, not including chlorination (which is to be added later):

Cost of power for aerator	$0.70
Cost of power for pumping	0.38
Cost of incinerating screenings	0.35
Cost of extra labor	0.47
Total per m.g.	$1.90

Results—The improvements have not been in operation long enough to warrant drawing definite conclusions, but a marked improvement both in appearance and odor is noticeable and the success of the venture will depend largely on the vigilance of the operator. The odor investigation was made by me in connection with the city engineer of Whittier, and the improvements were designed by Black & Veatch, who also designed the original installation. The construction was handled by M. R. Bowen, city engineer, on a force-account basis.

IMPROVEMENTS AT TULARE MUNICIPAL SEWER FARM

By W. M. BROWN*

In submitting this paper on the sewage disposal plant of the city of Tulare, I do so with a great deal of trepidation, as I am far from being a thorough sanitary engineer. I was elected mayor, serving from 1923 to 1927, then councilman from 1927 to 1931, re-elected councilman in 1931, and became city manager on July 1, 1931. Taking altogether the time I have served the city of Tulare, I have had a good chance to watch proceedings at the sewer farm and also to note what has been done to try to rectify any nuisances, such as flies, mosquitos, odors, and disposal of wastes and water.

Up to the time that I first took office (1923) the city of Tulare had leased the farm to a tenant. Thereafter we started operating under the charter form of government. We appointed a city manager and he started immediately to try to rectify the mistake of leasing the farm. Complaints were going to the State Board of Health about the condition of the farm. The surface of the land, while flat, was uneven. This caused pools of water to form, which became breeding places for flies and mosquitos, and also caused foul odors. The plant at this time consisted of two Cameron tanks which were not working very satisfactorily.

In June 1924 Tulare applied to the State Board of Health for a permit to build an activated sludge plant, using the Cameron tanks, which, after alterations and additions, were to become part of the new activated plant and were to be used as pre-sedimentation chambers.

The new plant consists of the two septic tanks, which had two compartments with an average depth below water line of 6½ ft. These tanks are without covers. There are two motor-driven flights in each tank, which convey sludge to the hoppers at the ends. These hoppers have 45-deg. slopes where the sludge is removed to the digestion tank. The flights consist of drags weighing 1600 lb. each, suspended from wheels riding on shelves in the septic tanks, operated through the water by a 2-hp. motor connected with a jack shaft and pulleys. The sludge is pumped to a separate sludge digestion tank with a sloping bottom and a capacity of 50,000 gal. The sludge is finally pumped to sand beds. The sludge tank is covered with a concrete roof.

The four aeration chambers are each 10 by 70 by 10 ft. deep, the cross-section resembling the Manchester type of aeration. Two rows of filtros plates run longitudinally the entire length of each unit. Air is supplied to the aeration tanks from any of three Connersville Boston-type blowers, each with a capacity of 300 c.f.m. at 5 lb. pressure per sq. in., operated by a 10-hp. direct-connected motor.

* City Manager of Tulare.

There are two settling tanks 20 by 25 ft., with baffles at the inlet and outlet. The outlet is over a 20-in. weir opposite the inlets. Sludge is pumped from the bottom of each of these settling tanks through a 6-in. cast-iron air lift, discharging sludge into the aeration tanks.

On July 17, 1924, the city of Tulare passed a $165,000 bond for construction of a disposal plant and installation of storm sewers. At this time the population was 5600 and the plant was designed to take care of 7000 population.

At the present time we have four creameries operating within the city limits. Consequently, our sewage problem here is disposal of creamery waste. Cream or whole milk is delivered by trucks, mostly in 10-gal. cans. The cream is usually made into butter, and the buttermilk is condensed for shipment. Raw milk is separated and the cream made into butter or pasteurized and shipped. The skimmed milk is acidified and made into cottage cheese. The whey produced and the first wash of whey is run to the sewer, if not wanted for hog feed. Skimmed milk is also sent to a casein plant, where it is acidified with sulphuric acid and casein produced. The spent whey from this process is also sold or given to farmers for hog feed if they will take it. But the demand for hog feeding is variable, as is also the demand —and hence manufacture—of casein. Otherwise the whey goes to the sewer, as also do the remaining vat washes. The whey waste varies in strength from forty to one hundred times that of domestic sewage. Its food value is from half to three-fourths that of skimmed milk, and it therefore makes valuable hog feed. But the supply exceeds the demand frequently, and the remainder goes down the sewer.

One creamery company in the city manufactures powdered milk, so we get nothing from them but the floor washings. All buttermilk is thickened in a vacuum condenser, the condensate, including some organic matter, and the water which seals the vacuum pump going to the sewer. The water seems harmless but contains some milk solids. All during plant operation wash-water is freely used. All floors are constantly washed down, and cans, churns, and pasturizers are cleaned throughout the day. Faucets remain upon during nearly 20 hours per day. All this water runs to the sewer over the floors, constituting a waste called floor wash. This is a dilute milk about five times as high in putrescible and organic constituents as ordinary sewage, and is equivalent to the sewage of, say, 10,000 persons. Water at the creameries is pumped from private wells and, being inexpensive and plentiful, is used freely.

Of the total flow of 264,000 gal. from the dairyman's creamery, 200,000 gal. came from rinse water from washing cans, equipment and floors; 46,000 gal. originated from condensers, some of which includes water evaporated from buttermilk; and 18,000 gal. was particularly strong wastes. The 200,000 gal. of floor wash was made up of 110,000 gal. during the day and 75,000 gal, at night from floors and cans, and 15,000 gal. from butter churns. (The latter is strong waste.) The Los Angeles creamery produces waste of 60,000 g.p.d.

Creamery wastes have been experimented upon in the east, and

two highly instructive bulletins have been published. The first, dated August 8, 1923, is the Iowa College Bulletin No. 68, on 'Aeration Studies on Creamery-Waste Purification'. These experiments were made on 2% skimmed milk, approximating in composition the present sewage at the Tulare sewer farm.

I have mentioned this bulletin as it nearly states the creamery-waste condition existing in Tulare. Condensing the information contained therein as follows:

A creamery waste differs from ordinary sewage in many respects, but particularly in that it contains the carbohydrate lactose, which rapidly undergoes acid fermentation, thereby rendering the waste extremely refractory to septic-tank treatment.

The acid-producing constituents can be eliminated by direct oxidation. Four hours' aeration of 2 or even 3% skim milk with activated sludge was found to be sufficient to yield effluents which would not become appreciably acid in storage under anaerobic conditions, and which should therefore probably not be objectionable for admixture with municipal sewage in septic tanks.

An activated sludge may be developed in about 2 weeks from 2% skim milk. Aeration of 2% skim milk for 16 to 23 hours in bottles or barrels (with 20% activated sludge and 50 to 60 cu. ft. of air per gal.) effected marked reductions in turbidity, acidity, total solids, organic nitrogen and, particularly, oxygen consumed and oxygen demand. Reductions of 95 to 98% in the oxygen requirements were generally obtained.

Activated sludge treatment was more effective with 2% buttermilk than with skim milk.

With separately, partially aerated sludges, employing an aeration period of 6 hours and 15.6 cu. ft. of air per gal., there was an average reduction of 43.9 solids, 77.7% organic nitrogen, and 76.7 oxygen consumed and oxygen demand. Reducing the air supply to 11.4 cu. ft. per gal. and increasing the aeration period to 12 hours, resulted in about 20% greater reduction.

Elimination of 95% of the oxygen, requiring constituents from 2% skim milk or buttermilk, is not sufficient to yield stable effluents. Possibly better distribution of air, together with mechanical agitation, may give more stable effluents.

Milk wastes may be successfully treated by chemical precipitation with iron sulphate and lime. This treatment produces a clear, non-offensive effluent. The precipitated material has considerable fertilizer value. From 75 to 95% of the organic nitrogen can be removed from whey by adding a slight excess of lime over that necessary to neutralize acidity, boiling and then passing the cooled effluent through a septic tank and sand filter.

Such sand filter effluent is, however, even with 95% reduction of organic nitrogen, about two or three times as strong as a strong domestic sewage before treatment, and therefore cannot be discharged into a small stream without danger of causing nuisance, or death of fish. Further experimentation on the treatment of whey is needed.

Practically all the known processes of sewage treatment have been tried out upon these wastes with variable success.

After installing the new activated sludge plant, it worked very well on domestic sewage, but when the creamery wastes came in the sludge started to break up and our troubles began.

At the time the new plant was put in at the farm, we also put in the storm sewer, which has relieved the situation. Since then we have added to our sewers so as to handle creamery waste separately. We have two chlorination plants connected to these sewers and use about 125 lb. of chlorine per day. Upon its arrival at the farm, the creamery water is handled in cement-lined ditches, and after being

run onto the ground it is plowed under. In summer the effects of the chlorine lasts about 3 days, which gives us a chance to plow the ground.

We have also installed 3600 ft. of 16-in. cement pipe and 500 ft. of 24-in. pipe for distribution to diffffferent parts of the farm, thus eliminating open ditches. The cost of these lines was $4164 and they were laid in the early spring of 1931. There are seven outlets, controlled by gates on the lines, thus giving us full control in handling the water.

All weeds have been cleaned off the land. In 1927 and 1928 we raised two very fine crops of cotton. In 1929-30 and 1931 we raised milo corn, selling the crop at the farm for a 3-year average of $2800 per year.

We have found out that the only way to keep down odors, flies, and mosquitoes, is absolute cleanliness and watchfulness. Flowers and rose bushes have been planted, and the appearance of the farm at present is that of a well-kept private farm.

The operating cost of the farm is about $450 per month, including labor, power, feed for horses, and maintenance of machinery.

In closing I might mention as to the beautifying of disposal plants that there have been some arguments. Personally, I am in favor of anything that can be done to improve looks as well as general sanitary conditions.

Our efforts in the reduction of odors, flies, and mosquitos have met with marked success, and our only thought is to continue the good work.

1932 YOSEMITE SPRING CONFERENCE PAPERS

Published in the Journal of the National Federation of Sewage Works Associations and not re-published in the current C. S. W. A. Journal:

'Activated Sludge Sewage Treatment Plant at Folsom State Prison', by L. E. Rushton, assistant mechanical engineer, State Division of Architecture, Sacramento. Sewage Works Journal, Vol. IV, No. 4, July 1932, p. 674-679.

'Digestion of Bar Screenings', by A. M. Rawn, assistant chief engineer, Los Angeles County Sanitation Districts. Sewage Works Journal, Vol. IV, No. 6, November 1932, p. 982-983.

'Digestion of Garbage in Beccari Cells, with Analogies to Sludge Digestion', by Charles Gilman Hyde, professor of sanitary and hydraulic engineering, University of California, Berkeley. Sewage Works Journal, Vol. IV, No. 6, November 1932, p. 993-1001.

'New Thoughts in Sedimentation of Sewage', by Chester A. Smith, consulting engineer, Burns-McDonnell-Smith Engineering Co., Los Angeles. Sewage Works Journal, Vol. IV, No. 4, July 1932, p. 601-608.

'New Thoughts in Sludge Digestion and Disposal', by R. F. Goudey, sanitary engineer, Los Angeles Department of Water & Power. Sewage Works Journal, Vol. IV, No. 4, July 1932, p. 609-613.

1932 ANNUAL CONVENTION
San Diego
September 26-27, 1932
Headquarters, U. S. Grant Hotel

Program

MONDAY, SEPTEMBER 26

8:00 a. m. —Meet at Oceanside City Hall. Visit Oceanside plant, including septic tank and ocean outfall.

8:45 a. m. —Carlsbad Sanitary District plant inspection. Separate sludge digestion, chlorination, and ocean outfall.

9:30 a. m. —Vista Sanitary District plant inspection. Covered Imhoff tank and sprinkling filter.

10:30 a. m. —Escondido activated sludge plant inspection, including separate sludge digestion and chlorination. Demonstration by R. F. Goudey on bulking and de-bulking of sludge.

12:15 p. m. —Luncheon at Escondido.

2:00- 5:00 p. m.—Technical meeting, San Diego, with papers on:
(a) 'San Diego State Teachers College Plant', by B. D. Phelps.
(b) 'Sewage Analyses and What They Tell the Operator', by E. A. Reinke. Discussed by R. F. Goudey, T. R. Haseltine, Jane H. Rider, and D. Traviani.
(c) 'Unusual Conditions Encountered in California Sanitary Sewer Design and Construction', by Charles H. Lee. Discussed by A. M. Rawn and C. C. Kennedy.
(d) 'Chemical Sewage Purification at Palo Alto', by Ralph A. Stevenson. Discussed by Harvey O. Banks, Paul J. Beard, and A. M. Rawn.

7:00 p. m. —Dinner meeting. 'A Sanitary Correspondence', presented by L. B. Reynolds.

TUESDAY, SEPTEMBER 27

9:00 a. m. —Business meeting with reports of committees and election of officers.

10:30 —Discussion of three Yosemite Spring Conference papers:
(a) Chester Smith's 'New Thoughts in Sedimentation', discussed by C. C. Kennedy, A. H. Koebig, E. A. Reinke, R. F. Goudey, T. H. Haseltine, and A. M. Rawn.
(b) R. F. Goudey's 'Digestion and Disposal of Sewage Sludge', discussed by M. L. Crist, R. A. Stevenson, E. A. Reinke, and T. R. Haseltine.
(c) C. G. Hyde's 'Digestion of Garbage in Beccari Cells with Analogies to Sludge Digestion Problems', discussed by A. M. Rawn and P. J. Beard. (Also, by letter, by Wm. Gavin Taylor.)

Noon —Luncheon, with address of welcome by R. M. Gregory, Director of Public Works for San Diego.

2:00- 5:00 p. m.—Joint meeting with Engineers' Section, League of California Municipalities.
(a) Report of legislative committee on sewer-rental bill.
(b) 'Operating Experiences at Phoenix Activated Sludge Plant', by D. Travaini. Discussed by Jane H. Rider.
(c) 'Control of Anerobic Decomposition in Sewage Transportation', by Fred D. Bowlus and A. Perry Banta. Discussed by O. T. Steward and C. T. Henderson.
(d) 'Possible Pollution of Water Through the Use of Toilet Flush Valves', by Walter Putnam. Discussed by Jean Vincenz.

FIFTH ANNUAL C.S.W.A. CONVENTION AT SAN DIEGO, SEPTEMBER 26-27, 1932

By A. GILBERT DARWIN*

The fifth annual convention of the California Sewage Works Association at San Diego September 26 and 27, 1932, drew a registered attendance of 124. Besides an inspection of four sewage treatment plants in San Diego county, with an optional post-convention visit to three other plants near San Diego, the program included a series of important papers, live discussions, a business meeting with election of officers, and an annual dinner. Of particular importance was the legislative committee's report, and the association's adoption, of a bill for financing sewer maintenance and operation. There was also considerable discussion of a second proposed bill for financing the construction of sewers and sewage treatment plants so as to put them in a self-liquidating category and entitled to funds of the Reconstruction Finance Corp. This convention program and attendance typifies the earnest purpose of an association formed in 1928 to advance the fundamental and practical knowledge concerning the nature, collection, treatment, and disposal of sewage and industrial wastes and the design, construction, operation, and management of sewage works.

Plant Inspections, September 26 and 28

A caravan of 40 automobiles assembled at the Oceanside city hall early Monday morning to begin sewage treatment plant inspections in Oceanside, Carlsbad, Vista, and Escondido en route to San Diego.

Oceanside Plant—R. L. Loucks, civil engineer of Riverside, led the delegates to and described the design and construction of a Cameron-type septic tank and 12-in. Byers cast-iron pipe ocean outfall in the Oceanside sewer system. Oceanside is a beach resort on the Coast highway 38 mi. north of San Diego, population 4000. The Cameron tank was built in 1926 to serve a maximum population of 15,000, the original cost being $3000, with $5454 later added for roof repairs, following an explosion.

Carlsbad Plant—C. A. Bower, superintendent, Carlsbad Sanitary District, discussed the design and operation of his disposal plant, constructed at a cost of $27,225. This plant was designed to operate with 1500 to 2000 connections but now has only 44 connections and serves 250 people. The plant includes a Dorrco clarifier, digester, and sludge pump, and an ocean outfall, with provisions for chlorinating the effluent. Inspection showed that the flow of sewage is inadequate for flushing or efficient plant operation. Assessments of the sanitary district are one-third delinquent.

Vista Plant—Chester A. Smith, of Burns-McDonnell-Smith Engineering Co., Los Angeles, described the sewers and disposal plant of the Vista Sanitary District and conducted the delegates through the plant. The outfall sewers and mains are 8 to 12-in. vitrified clay pipe and the laterals are 8 and 6-in., also of vitrified clay pipe. The disposal plant includes a covered Imhoff tank, sludge beds, dosing tank, weir box, trickling filter, humus tank, and sludge pump. At present there are 150 sewer connections serving a population of 500. The outfall line and main sewers were designed for 5000 population and the disposal plant for 2500 population, construction being carried out in 1929 at a total cost of $108,408.

Escondido Plant—Alva J. Smith, of Black & Veatch, consulting engineers, Los Angeles, described the Escondido sewage disposal plant, constructed in 1929 at a cost of $55,469. This plant contains a pump house with wet well for incoming sewage and dry well for two Fairbanks-Morse raw-sewage pumps; a screening and distributing chamber; two hopper-bottom preliminary settling tanks; one mixing and pre-treatment chamber; four spiral-flow aerators; a final settling tank with Hardinge clarifier; a chlorination and weir-measuring basin with Wallace & Tiernan chlorinator; a re-aeration tank; sludge digester; and sludge beds. The effluent is

* Editor, 'Western Construction News & Highways Builder'. Reprinted from W.C.N. & H.B., issue of December 10, 1932.

wasted into Escondido creek. Raw sewage falls through a steel basket-screen in the pump pit, where rags and other large objects are removed ahead of the pumps.

The Escondido plant has a connected population of 2500, with 175,000 g.p.d. average sewage flow. Sludge is accumulated at the rate of 30 tons per day and is sold in bulk on the bed at $4.50 per ton. The plant is attractively landscaped.

Test Demonstrations—Immediately following inspection of the Escondido plant, a demonstration of bulking and de-bulking of activated sludge was given by R. F. Goudey, sanitary engineer, Los Angeles Department of Water & Power, assisted by S. M. Bennett, operator of the Griffith Park experimental sewage treatment plant. Goudey explained that the phenomenon of bulking is largely or entirely mechanical or physical. Small portions of apricot or tomato, a ripe fig, and an onion were used to bulk samples of the sludge, which were then de-bulked by weighting down with lime or sand.

A. M. Rawn, assistant chief engineer, Los Angeles County Sanitary Districts, assisted by A. P. Banta and Fred D. Bowlus, demonstrated a field control laboratory, mounted at the rear of a light runabout, by which tests of hydrogen sulphide, causticity, and chlorine demand can be readily made at any point in a sewer line.

Luncheon on Monday was served at Escondido to 98 C.S.W.A. members and guests, after which the caravan proceeded to San Diego to begin the formal program.

Optional inspection trips on Wednesday, September 28, included the San Diego County Farm, San Diego State Teachers' College, and El Cajon sewage treatment plants, and one of the outfall sewers for the city of San Diego. These inspections were under the direction of Ed Beale, chief plumbing inspector, San Diego Health Department, who was also chairman of the local arrangements committee.

Edgemoore, the San Diego County Farm, is at the town of Santee, 18 mi. northeast of San Diego. The sewage treatment plant for this farm was designed by G. C. Zuckweiler, chief of the San Diego County Division of Sanitation, for a population of 500; now serves 310 people; and cost $11,895. The plant contains a wet pit, pump and motor rooms, Imhoff tank, dosing chamber, sprinkling filter, sludge beds, and settling tank. Effluent may be disposed of as irrigation water for a cornfield or on a natural sand bed. Grease from kitchen wastes is trapped before reaching the plant.

The San Diego College plant, 8 mi. northeast of San Diego, has provisions for settling, chlorination, sprinkling and slow-sand filtration, and separate sludge digestion, effluent being used for campus irrigation. This plant was designed in the city engineer's office at San Diego along lines suggested by C. G. Gillespie, chief of the State Bureau of Sanitary Engineering; constructed under supervision of the city superintendent of streets at San Diego; and turned over to the state upon its completion in 1931. The plant design was based on a population of 3750, with an average per capita flow of 10 g.p.d. (over a 9-hour period), construction costs being $26,000.

Chlorine is applied through a Wallace & Tiernan unit at three points—in the raw sewage where it enters the settling tank, in the dosing chamber of the sprinkling filter, and in the sand trap after the effluent leaves the sand filter. Acid wastes from the chemical laboratory at the college are by-passed through a vitrified clay sewer to a cesspool; otherwise the sewers are of concrete pipe. The dosing chamber, equipped with a Pacific Flush Tank Co. siphon, discharges to a filter having 6 ft. of graded rock and 6-in. concrete tile drains. A Byron-Jackson centrifugal pump delivers the effluent from a 40,000-gal. concrete tank to the irrigation lines as needed, total pumping head 260 ft. Sludge and scum are removed by hand-operated skimmers, scrapers, and valves.

The El Cajon plant has a designed capacity of 195,000 g.p.d. and was constructed at a cost of $28,143 under the supervision of W. M. Rumsey, civil engineer. This plant contains a pump house; Dorrco clarifier, digester, and sludge pump; dosing tank and sprinkling filter; and final settling tank.

Convention Papers, Monday Session

The first technical session, held Monday afternoon at San Diego, was called to order by W. A. Allen of Pasadena, president, California Sewage Works Association.

B. D. Phelps, of San Diego, presented a paper on the 'San Diego State Teachers'

College Sewage Plant', where 'educated sewage' is obtained. This plant has just been briefly described.

E. A. Reinke, senior engineer, State Bureau of Sanitary Engineering, Berkeley, gave the second paper, his subject being 'Sewage Analyses and What They Tell the Operator'. Reinke noted that such analyses give a yardstick to measure plant efficiency; they show what sewage is and how it changes. The appearance of settled sewage and of final effluent is one of the simplest observations which the operator can make; odor is also a good indicator of conditions; the b.o.d. is a refined relative-stability test; a fertilizer-value analysis is valuable.

T. R. Haseltine, chief sewage plant operator at Salinas, in discussing Reinke's paper, observed that chemists are not agreed as to the best methods of test and that for purposes of analysis relationship formulas are needed. R. F. Goudey, also in discussion, emphasized that the use of the eyes, nose, and ears in plant operation is really worthwhile, laboratory tests merely corroborating these observations. Standard methods of sewage analysis are lacking at the present time. The tests for nitrogen and ammonia are 'bugbears'. Jane Rider, director of the Arizona State Laboratory, Tucson, reported that her state is in the kindergarten stage of sewage treatment and that the few plant operators in Arizona are not skilled in making tests. Miss Rider suggested that a standard plant report form from the state boards of health might encourage tests by the plant operators, also that some central laboratory should furnish standardized chemicals, particularly for d.o. and b.o.d. analyses. D. Travaini, operator of the Phoenix plant, said that his tests are taken on 24-hour composite samples and that, as this plant was built to eliminate an odor nuisance, the d.o. must be maintained well above a certain limit.

'Chemical Sewage Purification at Palo Alto', the third paper, was presented by Ralph A. Stevenson, research engineer, Great Western Electro-Chemical Co., Pittsburg, California. (This paper was published in full in the November 10, 1932, issue of 'Western Construction News and Highways Builder', p. 635 to 637.)

Discussion of Stevenson's paper was led by Harvey O. Banks, sanitary engineer, Palo Alto, who noted the mounting interest in chemical sewage purification. This process, as compared with biological treatment, is subject to easy and positive control and may be adjusted to meet seasonal and daily variations in character of sewage; costs of construction and apparatus for a complete-treatment plant are lower than for the activated-sludge process; power costs are almost negligible; the detention period is shorter; freedom from odors allows the plant to be located in congested areas. The problem of the tremendous volume of sludge formerly present in chemical treatment of sewage may be overcome by using the most effective coagulants and applying them most efficiently for the minimum of chemical. The Palo Alto sludge, consisting of spent ferric hydroxide, is returned from the second basin to the incoming raw sewage, improving efficiency in the first basin and permitting sludge to be removed from two basins at one point. The effect of iron in the 94 lb. of ferric hydroxide sludge per m.g. of sewage may be found to be important in treatment of that sludge. The sludge from the primary tank at Palo Alto is almost a dense black, the solids settling rapdily from the liquid to form a dense, granular mass. From the work of other investigators it is concluded that iron in the sludge may possibly be beneficial through shortened digestion time and a resulting sludge that may dewater better due to the weighting action of inert ferric hydroxide. Success in chemical treatment largely depends on proper design of mixing tanks and sedimentation basins. The tank arrangements and design and rotating speeds of the mixing paddles at Palo Alto insure proper mixing in the first and maximum floc development in the second tank. Inlet and outlet baffles in the sedimentation basin are curtain walls, with a series of openings and plates to dissipate the jet action, efficiency of sedimentation being improved by the use of this design.

Paul J. Beard, professor of bacteriology at Stanford, called the Palo Alto experiments a step in advance and the revival of a process long considered obsolete. The laboratory has been transferred to the field, where promise is given of high-grade treatment at the cost of low-grade methods. The chemical process should have particular interest from the standpoint of water conservation, as the present practice of cities going 200 mi. to get water and then contaminating it and dumping it into the bay is not economical. Properly-treated sewage effluent can be put onto farms for irrigation, even if it is not desired for drinking purposes. Contamina-

tion of shellfish and pollutation of bathing beaches is a big problem around San Francisco bay. The effluent of the Palo Alto plant is sterile and free from contamination.

In answer to a series of questions from Rawn, Stevenson reported that: (1) the ferric hydroxide sludge can be rejuvenated at the cost of the necessary chlorine; (2) a chlorine residual is always maintained; (3) chlorine demand of the final tank influent is 8 p.p.m.; (4) the detention period is 7 hours; (5) water content of the final sludge is 97%; (6) different sewage characteristics have no apparent effect on the process; (7) hydrogen sulphide reacts with the ferric hydroxide—this fixes the hydrogen sulphide and removes it as a source of odor; (8) labor costs are very low, occasional inspection of the chlorine and ferric-chloride feeders sufficing for intermediate treatment, with more attention required for complete treatment; (9) intermediate treatment involves a chemical cost of less than $5 per m.g.

'*Unusual Conditions* Encountered in Sanitary Sewer Design and Construction', a paper by Charles H. Lee, consulting engineer, San Francisco, was read by Walter N. Frickstad, city engineer of Oakland. Storm-water flow controls design capacity in the combination sewers of San Francisco and the East-Bay cities. Hydraulic grades should be used in determining sewer capacities. Tidal currents aid in sewage disposal by maintaining the oxygen content.

A. M. Rawn, in discussion of Lee's paper, referred to a new design of inlet structures and the work of Arnold, Tuttle, and Armstrong. The factors of low velocity, warm sewage, and high mineral-sulphur content result first in generation of hydrogen sulphide gas and then of an acid which attacks the sewer walls. As a consequence, vitrified-clay liners are specified on the walls of all large sewers in southern California. Inverts of sanitary sewers receive no attention but might well be lined to reduce their erosion, even though the flows of sanitary sewage are quite moderate. In the southcoastal beach towns the design order is reversed on account of the high Sunday and holiday and low week-day sewage flows.

C. C. Kennedy, consulting engineer, San Francisco, in discussing the combined sewers of Oakland and Berkeley, reported that the trend in this design was started by San Francisco and copied by the East-Bay cities. Grades leading from the hills to the bay in most areas are precipitous and there are no problems of septic sewage at low flow. Maximum detention in Berkeley sewers is 1 hour and 40 minutes. The combined system provides for underground drainage. In the case of the Strawberry canyon sewer, Berkeley, a team of horses engaged in trying to remove stoppage at the inlet during a heavy storm was swept into the sewer and carried to the bay. The driver's presence of mind resulted in his taking an automobile, hurrying to the outlet at the bay, and arriving in time to assist the team as it emerged from the sewer. One of the horses died!

Bills for Sewer Maintenance and Construction

At a special meeting between the C.S.W.A. legislative committee and the governing board following the afternoon session on Monday, J. C. Albers, city engineer of Glendale, presented his legislative committee's report. This committee met eight times during the past year, most of its work being devoted to a sewer rental bill which would cover maintenance and operation. The possibility of including construction costs in the provisions of the bill was discussed by the committee following action of several C.S.W.A. members at a conference with E. J. Schneider, northern California chairman of the National Committee for Trade Recovery (see September 10th issue, p. 513.) Arthur Bent, of Los Angeles, had advised that the Reconstruction Finance Corp. was not interested in financing sewerage projects unless they were self-liquidating on construction features as well as maintenance and operation. Bent suggested that two separate bills be presented at the next state legislature, one for construction and the other for maintenance.

Kennedy asked which was the more important, maintenance or new construction. The legislative committee could probably never obtain approval of the state legislature and the governor for a maintenance bill with the sewer construction feature attached; it might be better to run the chance of two separate bills.

Leon B. Reynolds, professor of sanitary and hydraulic engineering at Stanford University, announced the receipt of a letter from Charles D. Marx, chairman of the engineering board for the R.F.C. Reynolds expressed the opinion, drawn from

this correspondence, that to bring sewerage projects into a class where loans can be made by the R.F.C. they must be clearly self-liquidating. Ohio has passed the necessary legislation to meet the federal requirements and California should do likewise.

B. J. Pardee, city manager of Visalia, believed that the combined bill might carry and cited a recent decision of the State Supreme Court where a utility which buys a piece of machinery may pay for it on a lease contract. He cautioned that there would be danger in any project which could not show a profit.

A. H. Koebig, Jr., consulting engineer, Los Angeles, reported that a year ago a bill had been prepared to cover construction as well as maintenance, and that it was pronounced illegal by two lawyers. Texas separates maintenance and construction costs. The proposed California sewer rental bill for maintenance is not mandatory and not ad valorem. Indiana has just passed a bill giving public water supply and sewerage projects self-liquidating features as a means of emergency financing. Two separate bills should be endorsed for legislative action by the C.S.W.A.

A letter from Harold F. Gray, consulting engineer, Berkeley, was introduced. Gray warned that an emergency exists and that in order to enable sewerage construction to proceed under the stimulus of the R.F.C., special legislation must be devised at once to meet the 'self-liquidating' requirements. Separate bills might very properly be drafted for maintenance and for construction, with the latter drawn as an emergency act to take effect upon its passage and signature by the governor. Two provisions would restrict operations to the present emergency and prove that this is not intended as a permanent method of getting around tax limitations. These are: (1) to cover only the projects actually initiated within 2 years of the bill's final passage and signature; (2) charges to extend for not more than 15 years after initiation of the project.

Reinke suggested that the C.S.W.A. should present the idea, and not the verbage, of one or two bills in skeleton form, and then let the legislators write the acts. The reported reason for the failure of the sewage research bill in the previous legislature was that too many engineers were unable to agree on what it should contain.

W. T. Knowlton, sanitary engineer, Los Angeles city engineer's office, recommended two separate bills and that the present legislative committee should push through the maintenance bill.

Donald McMillan, city engineer of Ventura, moved that two separate bills be presented.

Ernest Bent, of the American Concrete & Steel Pipe Co., Los Angeles, felt that goodwill for a maintenance and operation bill had already been built up and that such a bill might pass by itself. Matters of financing new sewer cosntruction, however, are of great importance. With the present assessment acts and bond-issue methods there can be but little sewer construction within the next few years unless some such legislation as meets R.F.C. requirements is passed. A construction bill will be more difficult to draw than one for maintenance. With or without R.F.C. money available, a self-liquidating sewer construction bill on the state statutes would be a forward step in attracting private money to this work.

John Spencer, chief of the division of hydraulics, State Fish & Game Commission, San Francisco, suggested that the proper procedure is to work on the idea, omitting details. The motion was then voted on and carried.

Albers read a letter from Batty and Lewis, both of Los Angeles, protesting that safety laws for sewer inspection do not protect the maintenance crews and recommending that a set of adequate safety rules be drawn and submitted to the State Accident Commission.

A letter from A. K. Warren, chief engineer of the Los Angeles County Sanitation Districts, proposing the licensing of plant operators, was referred to the board of control.

The annual dinner on Monday evening was attended by 75 members and guests. Jane Rider, representing the seven Arizona delegates, called attention to the October 1933 meeting of the American Society of Civil Engineers at Phonix and invited members of the C.S.W.A. to be present. Leon B. Reynolds presented 'A Sanitary Correspondence', in the form of a series of letters between two sewer rats known as 'Steve' and 'Al'.

Convention Business, Tuesday Session*

(By E. A. REINKE)

On Tuesday morning, September 27, the annual business meeting of the association was held, with committee reports as follows:

Membership Committee—J. A. Harmon reported 220 members, a net loss of 17.

Publicity Committee—John Spencer reported little success in getting newspaper publicity for meetings.

Legislative Committee—J. C. Albers reported much activity on the sewer-rental bill, to be reported in detail at joint meeting with the Engineers' Section, League of California Municipalities.

Auditing committee, consisting of M. L. Crist, H. E. Shook, and A. P. Banta, reported treasurer's books satisfactory. Moved, seconded and carried that report be accepted.

Resolutions committee, consisting of C. C. Kennedy, J. C. Albers and A. M. Rawn, reported resolutions on safety regulations for workers in sewers; thanks to local committees; and congratulations to C. D. Marx of the engineering committee of the Reconstruction Finance Corp.

The secretary-treasurer's report was read and accepted.

Award Committee—Considerable discussion resulted from the suggestion of the committee that the award be given only for some outstanding work. It was finally moved, seconded, and carried that the plaque be given as heretofore, but no cash award be made.

Licensing of Operators—Moved, seconded, and carried that a committee of three be appointed to report at next annual meeting.

Sewage Research—Past-president B. J. Pardee spoke in favor of keeping sewage research alive, even if funds could not be made available at present, and the president announced that would be the policy since there was no objection.

Nominating Committee—J. F. Smith, chairman, presented the report of the committee and named two each for the offices of president and the two vice-presidents. C. C. Kennedy spoke in favor of continuing the policy of advancing the second vice-president to first vice-president and president, stating that such a policy was agreed on at the time of organization, largely on the advice of George W. Fuller. Kennedy felt that a large measure of the success of the association was due to this policy of getting men on the board 2 years before being elected president. After considerable discussion, the report of the committee was accepted. H. B. Hommon by mail withdrew his candidacy for president in favor of first vice-president Jacobson, who

*Abstract from official minutes.—Editor.

was unanimously elected president. R. F. Goudey withdrew as a candidate for first vice-president in favor of second vice-president McMillan, who was then unanimously elected. T. R. Haseltine was elected second vice-president; W. A. Allen, director; A. M. Rawn, board of control member; and E. A. Reinke, secretary-treasurer.

Following the business meeting, three papers presented at the Yosemite spring conference were discussed.

'New Thoughts in Sedimentation', by Chester A. Smith, was discussed by C. C. Kennedy, A. H. Koebig, E. A. Reinke, R. F. Goudey, T. R. Haseltine, and A. M. Rawn.

'Digestion and Disposal of Sewage Sludge', by R. F. Goudey, was discussed by M. L. Crist, R. A. Stevenson, E. A. Reinke, R. F. Goudey, and T. R. Haseltine.

'Digestion of Garbage in Beccari Cells with Analogies to Sludge Digestion Problems', by C. G. Hyde, was discussed by A. M. Rawn and P. J. Beard.

Luncheon was arranged by the local committee. R. M. Gregory, director of public works, welcomed the association on behalf of the San Diego city administration.

A joint meeting with the Engineers' Section of the League of California Municipalities was opened by D. M. True, who turned the gavel over to president Allen.

Chairman J. C. Albers and W. T. Knowlton of the legislative committee reported on the sewer-rental bill, announcing support by the league and by the State Department of Public Health. Members were urged to contact their legislative representatives.

Papers were presented as follows:

'Operating Experiences at Phoenix, Arizona, Plant', by Dario Travaini. Discussed by Jane H. Rider and C. C. Kennedy.

'Control of Anaerobic Decomposition in Sewage Transportation', by A. P. Banta and F. D. Bowlus. Discussed by O. E. Steward, C. T. Henderson, and E. A. Reinke.

'Water Contamination from Toilet Flush Valves', by Walter Putnam. Discussed by Carl Wilson and Jean Vincenz.

President Allen turned the meeting over to president-elect Jacobson, who thanked the members for electing him and asked their support for the coming year. The meeting was adjourned.

California Section, American Water Works Association, of which R. F. Goudey is president, will hold its fourteenth annual convention at Oakland, October 25-28, 1933; headquarters, Hotel Oakland. The common problems of water works and sewage treatment plant superintendents make this a valuable meeting to C.S.W.A. members subsequent to their own convention.

DEMONSTRATION ON BULKING AND DEBULKING OF ACTIVATED SLUDGE AT ESCONDIDO PLANT

By R. F. GOUDEY*

During the past 2 years I have conducted literally thousands of tests to fathom the mystery of 'sludge-bulking'. Other writers have blamed sludge-bulking onto microscopic organisms, such as Sphaerotolus, and bacterial filaments. Sludge cannot be bulked by pure cultures of these organisms, nor is it possible for them to multiply with the speed that bulking occurs. Bacterial filaments multiply on fruit and vegetable pulp, but their presence in greater numbers than found in bulked sludge has been observed in dense, heavy sludge. Like many other problems, the answer is too close at hand and too simple to be found except at the end of a lot of laborious work. After all is said and done, sludge-bulking appears to be simply a physical suspension of activated sludge, held up by inorganic or organic substances themselves too light to settle rapidly.

Activated sludge is said to be bulked when for the same weight of sludge its volume is increased. The first part of the demonstration was to collect two samples of aeration-tank liquor in 1000-c.c. graduates. Apricot pulp, equivalent to one-fourth of a dried apricot, was placed in one sample. Both, presumably, had the same weight of activated sludge. After 1 hour the blank sample settled to 30%, whereas the bulked sample settled only to 90%. The latter sample showed three times the volume for the same weight of sludge in the blank, and was accordingly called 'bulked'.

The second part of the demonstration was the bulking of activated sludge with milk of magnesia—just one of the many inorganic substances which will bulk sludge—followed by debulking with the addition of lime. Three 1000-c.c. graduates were used. Two of these were filled with aeration-tank liquor diluted to settle to 30% in 30 minutes, and one was filled with well water. A teaspoonful of milk of magnesia was added to the well-water sample, and one teaspoonful to one of the activated sludge samples. The following table gives the volumes after 5 minutes settling, together with the volumes after lime had been administered. The well-water sample showed a suspended floc. The treated activated sludge was apparently held up by the same suspension. The addition of lime precipitated the magnesium sharply, and the taking away of the support in the bulked sludge caused it to become normal.

The third part of the test demonstrated bulking due to various fruit pulps. These were prepared in advance and aerated 1 hour before the demonstration. One sludge sample was kept as a blank. An apricot-pulp suspension was made in a well-water sample with no activated sludge. Some of the samples were debulked with lime, one

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with fine silica sand, and one with powdered decomposed granite in an effort to prove that the debulking process was purely physical sedimentation.

Generally speaking, anything which is laxative to man tends to bulk sludge, whereas constipating substances tend to debulk.

A fuller report on this subject, covering effects of pH, other substances used to bulk sludge, and longer experiments will be made at a later date.

BULKING WITH MILK OF MAGNESIA AND DEBULKING WITH LIME

Sample	Per Cent Settling, 5 Minutes	
	Bulked	Unbulked
Well sample	80	20
Blank sludge	50	50
Sludge bulked with magnesia	75	40

BULKING WITH ORGANIC SUBSTANCES AND DEBULKING WITH LIME AND INERT MATERIALS

No.	Sample Activated sludge in all but blank	Percent Settling 5 Min. Bulked	Debulking Agent	Percent Settling 5 Min. Unbulked
1	Blank	50	.....	50
2	¼ Apricot	95	Lime	60
3	¼ Tomato	95	Lime	30
4	1 Small Fig	95	Sand	30
5	1 Small Onion*	95	Granite	30
6	Well Water with ¼ Apricot	80	Lime	20

* Onion, like many other organic substances, requires an addition of an alkali, followed by neutralization, to produce a non-settling suspension.

SAN DIEGO STATE TEACHERS COLLEGE PLANT

By B. D. PHELPS*

The city of San Diego has solved a problem in sewage treatment that has proven very satisfactory to all concerned. The location of the new State Teachers College in a district that was not served by a sewage system caused considerable study. The topography of the ground adjacent to the building made it possible to run the sewage by gravity to the side of a canyon. After considerable study on a contour map, the plant was laid out so that all the different units were supplied by gravity, thus eliminating pumping. The final effluent is then stored and pumped up into the irrigation system around the campus. Due to the high price paid for water in San Diego, this feature of using reclaimed water was very desirable.

The design was different from the general run of sewage plants; as in this case it was found that the school was open about 9 hours per day and that the average consumption of water was 10 g.p.d. The ultimate college attendance is to be 2500 persons.

The plant consists of a settling tank of sufficient size to retain the ultimate flow 2 hours, using as a peak flow 15 gal. per capita.

The sludge is pushed to the end of the settling tank by a hand-operated scraper. A sluice gate at the end of the tank allows the sludge to be drawn off and distributed along the top of the sludge-digestion tank. The effluent is drawn off through a header pipe with nipples extending below the surface of the sewage, thus eliminating the chance of anything except clear effluent getting into the dosing tank.

The effluent from the dosing tank discharges onto a rock filter 5 ft. deep, consisting of 1½-in. rock on top and 3 to 4-in. rock around the drains on the bottom. The effluent then runs through a small settling basin that collects the floc passing through the rock filter. At this point valves are installed to allow the time of emptying the settling tank to equal the average time between operations of the dosing tank.

The effluent next flows to two sand filters, constructed 7 ft. deep and filled up 4 ft. with gravel and sand. The 3-ft. freeboard is to allow for storage of water, and the rate of flow from the sand filter is regulated by a float valve, so that the 9-hour flow is distributed over the 24 hours. A backwash line is connected to the pumps to wash the sand filters.

The effluent then passes through a sand trap into a storage tank that holds a 3-day supply, and is pumped to the irrigation system when needed. The overflow runs to a cesspool in the creek bed.

Odors are controlled by applying chlorine through a W. & T. unit at three points in the course of treatment.

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SEWAGE ANALYSES AND WHAT THEY TELL THE OPERATOR

By E. A. REINKE*

Sewage analyses are being made at many disposal plants and the question is frequently asked, "Just what do they tell the operator?" The usual answer is that they give him a yardstick to measure the strength of sewage and the results of treatment. The more familiar the operator is with the processes at his plant and the sewage it receives, the more the analyses will tell him and the better will be the results.

Sewage: What it Is and How it Changes

Sewage is the waste water of a community, containing discharges from households and industries, street washings, and the like. It is usually 99.9% water and only about 0.1% solids. The problem of the operator is to remove or change a portion of the solids in his treatment plant so the materials produced will not be offensive or a menace to health.

The solids present in sewage may be floating, settleable, in solution, or in a finely-divided suspension termed 'colloidal'. The floating solids are objectionable to the senses and a frequent cause of complaint; they may usually be removed by skimming in settling tanks. The settleable solids are also usually removed as sludge in settling tanks. The solids in solution or colloidal form are more difficult to remove or change, this work being done in an oxidizing device—usually an activated sludge plant or a trickling filter.

The foreign materials in sewage, including solids, are usually classified as stable or unstable. The stable materials include such things as sand and grit, and minerals in solution normally present in varying amounts in the water supply. The solid particles must be removed, and present a physical problem, while the minerals in solution are ordinarily not a problem. The unstable materials are body discharges, fats and oils, fruit and vegetable wastes, and industrial wastes. These are complex organic compounds which may be generally classified as carbon-containing, or carbonaceous, and nitrogen-containing, or nitrogenous.

Certain of the carbonaceous materials, such as sugars and starches found largely in fruits and vegetables, are readily broken down by a combination of bacterial and chemical action, termed biochemical, to produce simpler compounds such as methane and carbon dioxide, which are the principal constituents of gas from sludge digestion. Other materials, such as paper or cellulose, break down more slowly, usually under anaerobic conditions, which means by bacterial decomposition in the absence of atmospheric oxygen.

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Nitrogenous materials, such as meat, eggs, and milk, break down to form ammonia, nitrites, and nitrates. Solid nitrogenous materials are usually liquefied by bacterial action, with the production of ammonia. Urea is quickly broken down to ammonia, and is usually absent in sewage as it reaches a treatment plant. The change from ammonia to nitrite and nitrate is slower, and usually takes place in oxidizing work by the action of aerobic bacteria, or those that thrive in the presence of atmospheric oxygen.

Fats, oils, and soaps which occur in varying amounts in sewage are changed slowly and with difficulty. They are associated with most of the scum troubles in settling and digestion tanks.

Sulphur Compounds—In addition to the nitrogenous and carbonaceous materials, some sewages contain sulphur compounds which, under anaerobic conditions, produce hydrogen sulphide and other odorous compounds. These are probably the source of most odor nuisance complained of along sewer systems and around disposal areas.

'Standard Methods for the Examination of Water and Sewage', as published by the American Public Health Association and the American Water Works Association, give detailed instructions for making the more common tests. Instructions regarding sampling and preservation of samples should be followed and noted on all reports of analyses. In general, it is advisable to use these standard methods. This paper is in no sense a critical review of standard methods, but an attempt to show something of their value to the plant operator and their limitations. A number of simple determinations not mentioned in them can be and are frequently made by the operator, and some modifications of standards are of value for particular sewages. Among these are appearance, settleable solids, and per cent sludge.

Appearance is one of the simplest tests—or observations—which the operator can train himself to make. The test is only qualitative, and judged by visual observation. Raw sewage may be clear, colored, milky, soapy, filmed with oil or grease, or possess other characteristics which if recorded by the operator will enable him to explain some things which occur later in the plant. Many of you have heard an operator say, "I had a heavy shot of oil this morning and the plant hasn't recovered yet" Sometimes the event is noted in a column on remarks, but usually it is only a passing observation. Appearance of settled sewage and final effluent will tell the trained observer whether the plant is producing good, fair, or poor results, and to the visitor the appearance of the final effluent probably leaves the most lasting impression.

Settleable solids is another simple test frequently used, although not included in standard methods, and is determined by use of the Imhoff cone. This gives solids in c.c. per liter settling in a given time, usually 2 hours, and is a rapid test for indicating the performance of settling tanks. If the effluent uniformly shows from a trace

to 0.2 c.c. per liter, the operator knows that he is getting at least reasonably good results from his settling tanks.

Per Cent Sludge—A similar test is settleable solids in activated sludge, usually made in a graduated cylinder and reported as per cent sludge after 30 minutes to 1 hour settling. Recently the tendency in plants having adequate laboratory facilities has been to supplement this test by the suspended-solids test (which will be discussed later), chiefly because of marked variations in sludge density and sludge bulking. For the small plant, however, the per cent sludge determination is of value as a routine test. The operator can also make observations as to the relative rate of settling, the appearance of the sludge, and the time it will stay down at room temperature, all of which are of value in forestalling trouble.

Physical Examination—Odor: Turbidity, color, and odor are mentioned in standard methods as tests which may be made as in water analyses, if desired. Turbidity and color may be of value in tests of high-grade effluent, whereas the odor determination has many valuable uses. Odor is a most important, yet baffling test. It is probably better not to attempt a test, but simply to record kind and intensity of odors around various parts of the plant and correlate them with other tests. For example, sour odors would be expected with low pH tests; rotten-egg odors with high-sulphide tests; chlorinous odors with high-residual chlorine tests; etc.

Odors may be observed at various times of day and around various units of a plant, including influent channel, screens, inlet and outlet to various units, sludge beds, screenings and scum disposal areas, and others as experience indicates. The purpose of such records is twofold: first, and usually most urgent, to check on production of odors which may cause nuisance complaints; and second, to note any change in sewage operations which might cause inferior results. Another advantage of odor records would probably be improved housekeeping around the plant, since cleanliness is one of the means of keeping down odor production.

Dissolved Oxygen—This test is a measure of atmospheric oxygen in solution in a given sample, and is primarily used as part of the b.o.d. determination or in sampling streams receiving plant effluent. It is of value in checking the presence of dissolved oxygen in aeration units of activated-sludge plants. The Winkler method with various modifications is described in considerable detail in the May 1932 'Sewage Works Journal'. When interfering substances such as organic matter, nitrites, ferrous and ferric iron, or free chlorine are present, it is essential that the procedures outlined be followed to avoid possible gross errors.

Relative Stability—As a final effluent is produced it still contains a certain amount of unstable, and therefore oxygen-demanding material, and on the other hand a certain amount of oxygen supply, as free air or as nitrites and nitrates. Under bacterial action at a definite temperature, the latter becomes used up by the former. The period

consumed gives a means of measuring the percentage relationship of oxygen demand to oxygen resources in the sample.

The test for disappearance of the oxygen supply is made by adding a certain amount of a dye (methylene blue) to the sample. The blue color disappears when the oxygen is gone. Most of the oxygen demand is exerted in 20 days. The test is simple. A continuous record of samples which stand 10 to 20 days without decolorization is good, and an unbroken series of blue bottles in the incubator tells an eloquent story to the operator and the informed visitor. It is of value only on oxidized effluents and in the absence of disinfectants, causticity, or other constituents which might in themselves delay the bacterial action or decolorize the dye.

Biochemical Oxygen Demand—The 5-day b.o.d. of sewage and effluents by dilution method, in which varying amounts of sample are mixed with water of known dissolved oxygen content and incubated for 5 days, the amount of oxygen used up being determined and recorded, is one of the most common and useful tests available to the sewage works operator. It gives a measure of the strength of the sewage or effluent and removal of oxygen-demanding constituents. Its limitations are that 5 days are required before results are available, and that several bottles are required for each sample to make certain that proper dilutions are obtained.

In raw sewage the test indicates changes in strength from day to day; in settled sewage it gives a measure of loading applied to oxidation works; and in final effluent it measures the load to be placed on a receiving stream or the likelihood of the effluent becoming putrescible.

Total Solids—This test, in which a sample is evaporated to dryness and weighed, gives the combined dissolved and suspended solids in sewage, and by itself means little, since a highly mineralized water will have a high total-solids content even with very little suspended matter present. It is of value chiefly as a part of the suspended-solids tests.

Suspended solids may be determined by evaporation of filtered and unfiltered samples and getting suspended solids by difference in weights of residue; or by use of the gooch crucible, in which the sample is passed through an asbestos filter mat and dried, the weight increase giving a measure of the material caught. As the name implies, the test measures the solids in suspension, as against those in solution. In settling works, suspended solids give a measure of removals obtained by difference of raw and settled samples and a check on the dry solids in the sludge. In final effluents the test indicates the likelihood of sludge formation in the receiving stream.

Nitrogen Cycle—The change of nitrogenous material from organic combination to ammonia, nitrite, and nitrate has for many years been used as a measure of plant efficiency. Tests of the various forms of nitrogen at different sampling points give a measure of the degree of stabilization effected by various units of the plant. Free ammonia,

organic nitrogen, nitrite, and nitrate determinations are useful in large plants where laboratory facilities are available. When correlated with other tests, and particularly with operating procedure, they may be specially valuable to the trained operator in effecting operating economies. In small plants it is probably wiser to use only simpler tests which require little laboratory equipment, using excess capacities as factors of safety. The cost of excess capacity will be largely offset by reduced costs of personnel for operation and laboratory control.

Free ammonia and nitrite may be determined quickly by colorimetric methods, and in some smaller plants—particularly those of the activated-sludge type—these tests might be made as part of the routine analyses. If the operator finds that good results are always obtained when free ammonia is below a certain critical value and when nitrites are present in certain amounts, these tests may tell what uniformity of results is being obtained and indicate need for changes of operation.

The oxygen-consumed test, in which a sample is boiled with acid and permanganate for 30 minutes to chemically oxidize the organic matter present, is a measure of the carbonaceous materials in sewage. It is one of the oldest tests we have and has not been as much used in recent years as newer tests. The 30-minute boiling requires time, and apparatus is necessary which most operators feel cannot be justified by results.

English practice has been to use both 3-minute and 4-hour periods at room temperature, which give simplicity but have not been generally adopted in this country. Because of the short time and few laboratory supplies involved, these English tests seem to have some advantages over the 5-day b.o.d. test, particularly for small plants. In fact, the British Ministry of Health Committee recommends them for small sewage works. If factors were available to show the relation of oxygen consumed to b.o.d. for any given sewage, we might expect these tests to be popular among operators.

Grease (Fats)—In the test for grease, petroleum ether is used to dissolve fatty substances. The ether is then evaporated and the residue, or fatty substances, is weighed. This test is particularly valuable on raw sewage, as it tells when excessive quantities are reaching the plant and gives an argument for use of grease-removal devices or control of oil and grease discharged to the sewers. Modifications of the test can also be made to tell the form in which it occurs.

Alkalinity as $CaCO_3$, in which the sample is titrated against standard acid with methyl orange as an indicator, is a relatively simple test. In plants producing oxidized effluents good results are accompanied by marked reduction in alkalinity. Since the test measures the breaking down of the carbonaceous materials, it should correspond roughly to the oxygen-consumed test.

As a matter of interest Table I has been prepared showing the removal of alkalinity at several treatment plants in this state, the per cent removal of excess alkalinity over that normally found in the city water supply, and comparison with removal of oxygen consumed.

A direct measure of the removal of alkalinity, and particularly percentage removal, does not tell much because of variations of alkalinity in water supplies. The correlation between alkalinity reduction and oxygen-consumed reduction is good, however, when considering the excess alkalinity over that present in the city supply.

pH of hydrogen-ion concentration is a term indicating the degree of acidity or alkalinity of a sample. In sewage analyses it has been used to cover a multitude of sins. Slight variations of 0.2 to 0.3 in pH are of doubtful significance. The test is easily made colorimetrically with any of the several outfits on the market. Any marked change can be checked by additional tests. In treatment plants the pH values seem to smooth out and approach neutrality, or pH 7.0, as the sewage passes through. Values above 7.0 are on the alkaline side and values below on the acid side.

With chemical treatment, as would be expected, a wide variation is found, and for any process it may be necessary to control pH accurately.

Chlorine tests are of little value except when it is proposed to use the sewage effluent for irrigation or industrial purposes. In such cases it is important to keep the chloride content at a minimum, and the records of the test can be used to advantage in controlling discharge of unusual amounts of salt to the sewers, as for example from water softeners.

Residual (free) chlorine is determined colorimetrically on chlorinated sewage or effluents, usually after a definitely stated period of standing. A number of test outfits are on the market, all using the same reagent, orthotolidin. Among interfering substances are iron, manganese, and nitrites. These can usually be checked in samples before chlorination. If iron is present the sample should be read within 30 seconds after adding the reagent; if manganese is present the difference between samples before and after chlorination will measure the amount present.

With nitrites the test is difficult, particularly if free ammonia is also present. If the test is doubtful, a qualitative confirmation can be made by adding a solution of Na_2CO_3 to get a pH of 3.5, at which the orthotolidin color becomes blue or blue-green. With neutral samples if 0.5 c.c. of orthotolidin is added to 100 c.c., about 1 c.c. of 3.5% Na_2CO_3 will produce the required pH.

Residual chlorine is usually checked to make certain that a sufficient quantity is being added for disinfection and supplementary tests for bacteria and B.coli should be made from time to time.

Hydrogen sulphide cannot be determined in sewage by the 'standard-methods' procedure for water. We have found the use of antimony potassium tartrate—first reported in the 1929 'California Sewage Works Journal', with modifications by H. E. Johnson, as described in the April 1931 'Sewage Works Journal'—satisfactory. It should be mentioned, however, that this tests soluble sulphides rather than

only H_2S and if sufficiently shaken all will be found volatile. The test is valuable in connection with odor complaints and control of chlorine treatment on sewer systems.

Iron tests are of advantage only under special considerations, and would not be included in general routine work.

Microscopical Tests—In larger plants, particularly of the activated-sludge type, the use of microscopical tests of the kind and number of micro-organisms present will probably be of increasing importance. Information as to desirable and undesirable flora is meagre, and quantitative data are lacking. The field of usefulness of such tests seems very large in biological treatment works and we may expect rapid changes in the not far-distant future.

Bacteriological Tests—Chlorination of sewage and effluent has resulted in requirements of bacterial removal, and tests for total bacterial count on agar and numbers of B.coli per c.c. are frequently made at sewage treatment plants. They measure primarily the efficiency of chlorination.

Bacteriological tests for various species of bacteria in activated sludge may also be made more frequently in the future, particularly in connection with microscopical work. Up to the present time, both these tests have been primarily of a research nature, but before long they may be routine operating procedure.

Sludge Analyses

Appearance and Odor—Digested sludge when wet is usually dark brown or black, gelatinous, of uniform texture with gas bubbles, and has a tarry or earthy odor. If gray or yellowish brown, greasy, watery, and odorous, it is not properly digested.

Activated sludge is golden brown, flocular, with clear liquid between sludge particles, and has a slight, inoffensive, musty odor in the aeration tanks. It settles rapidly in test cylinders and stays down from a few hours to a day, depending on temperature and condition of sludge. If sludge is in poor condition it may be light gray to black, odorous, will not settle readily or, if it does, will stay down only a short period, and liquid between sludge particles will usually be milky or cloudy.

Settleable Solids—Per Cent Activated Sludge—This test is a useful one in activated-sludge plant operation. In aeration units the solids settling in 30 minutes will usually be 5 to 40% and in reaerated sludge or return sludge from final settling tanks 50 to 99%. These values may vary with operating schedule and times of day, and proper limits must be determined for each plant.

Per Cent Moisture—Volatile and Ash—Raw sludge generally contains 90 to 98% moisture or 2 to 10% dry solids, depending on the character of the sewage and the method of settling and collecting. A

record of the per cent moisture is of value in determining the period of storage in digestion units.

Volatile matter varies from 60 to 80% of the dry weight, the remainder being ash. For combined sewers, or at times of storm, the volatile matter may be less than the amounts indicated.

Digested sludge may contain 90 to 95% moisture or 5 to 10% dry solids. Volatile matter ordinarily comprises 40 to 55%, depending on the amount present in the raw sludge and the degree of digestion. Records of per cent volatile in raw and digested sludge give a measure of the degree of digestion.

We have no good definition of digested sludge, but for practical purposes sludge is sufficiently digested if it will dry readily on open beds without giving off objectionable odors. Incidentally, the more thoroughly digested the sludge, the poorer its value as a fertilizer, and when so used this process should be carried only far enough to avoid nuisance while drying. When no laboratory tests are available, a record of per cent shrinkage on beds will give a rough measure of the water content of the applied sludge.

Activated sludge ordinarily contains 99.5 to 99.85% moisture, or 0.15 to 0.5% dry solids. The dry solids will be slightly higher than the suspended solids, because of the mineral content of the water and the organic material in solution, which are included in the dry (or total) solids test but filtered out in the test for suspended solids. Volatile matter in activated sludge may vary from 45 to 80%. The significance of this test is doubtful, but in general the better sludge will have a lower volatile content.

Fertilizer Value—When sludge is used as fertilizer, analyses of samples for available nitrogen, phosphates and potash should be made.

Activated sludge has total nitrogen available of 3 to 6%, phosphates as P_2O_5, 1.5 to 3.0%, and potash as K_2O, 0.3 to 0.6%.

Digested sludge has total nitrogen available of 0.8 to 3.6%, phosphates as P_2O_5, 0.6 to 2.0%, and potash as K_2O. 0.2 to 0.8%.

These tests are of value chiefly for sales purposes.

Grease or fats in sewage sludge vary from 5 to 25% and are decomposed to stable constituents with difficulty. In general, a sewage with high grease content will produce a sludge with high grease content.

pH or hydrogen-ion concentration of sludge is usually determined colorimetrically on a diluted sample or after filtration. The present tendency is to collect samples of supernatant liquor just above the sludge level as an indication of true pH, because of errors and difficulty of determinations on samples of the sludge itself. With reasonable care to avoid aeration, we have found filtration through filter paper or cotton to give results within 0.1 pH, which is sufficiently accurate for practical operation. When sludge pH is neutral or slightly alkaline, conditions are considered good for digestion. For sludge conditioning, special indicators must be used to measure the optimum pH desired.

TABLE I

COMPARISON OF ALKALINITY AND OXYGEN CONSUMED

	Lodi	Salinas		Pasadena	Pomona	Escondido	Santa Barbara Hosp.	San Bernardino	Ojai	San Diego State College
		All	Half							
Alkalinity										
1 Raw	267	420	440	252	304	317	350	256	438	250
2 Final	242	376	257	181	140	205	292	130	221	190
3 Removed	25	44	183	72	156	112	58	125	216	60
4 City water	140	220	220	125	120	152	280	150*	144	120
Excess raw over city water	127	200	220	127	184	165	70	106	294	130
% Excess removed	20	22	83	57	85	68	83	100*	73	46
Oxygen Consumed										
Raw	47	214	232	223	194	163	190	174	272	122
Final	28	81	56	56	60	62	40	62	54	44
% Removed	40	62	76	75	69	63	79	64	80	64
Ratio $\frac{\%\text{ Alkalinity Removed}}{\%\text{ Oxygen Consumed Removed}}$	0.50	0.36	1.1	0.76	1.2	1.1	1.05	1.5*	.91	0.72

*City water, alkalinity estimated.

TABLE II A

Suggested Tests and Observations by Operator

Raw sewage	Appearance	Unusual conditions
	Odor	Age and possible nuisance
	Settleable solids	Solid particles
	pH	Acid, alkaline, or neutral
	Sulphides	Sulphur compounds
	Temperature, °C.	
Settled sewage	Appearance	Unusual conditions
	Odor	Septic action, if any
	Settleable solids	% removal
	pH	Acid, alkaline, or neutral
	Sulphides	Sulphur compounds
	Temperature, °C.	
Oxidized effluent	Appearance	Excellent, good, fair, or poor effluent
	Odor	Should be odorless
	Settleable solids	Solid particles
	pH	Acid, alkaline, or neutral
	Residual chlorine	Disinfection
	Relative stability	Satisfactory effluent
	Temperature, °C.	
Sludge	Appearance	Roughly degree of digestion
	Odor	Possible nuisance
	pH	Acid, alkaline, or neutral
Activated sludge	% activated sludge	Sludge in plant
	Rate of settling	

TABLE II B

Suggested Additional Tests and Observations by Plant Chemist

B.O.D.	Strength
Suspended solids	Sludge to be expected
Total organic N.	Strength (N)
+ free NH_3	Strength (C)
Oxygen consumed	Increase over city water
Alkalinity (Alkalinity of city water)	Solids and salts
Total solids	
B.O.D.	Strength and % removal
Suspended solids	Sludge removed
Total organic N.	Strength and % removal
+ free NH_3	Strength (C) and % removal
Oxygen consumed	Change on settling
Alkalinity	Sludge removed
Total solids	
B.O.D.	Stability and % removal
Suspended solids	Sludge in effluent
Nitrite	Degree of nitrification
Nitrate	Degree of nitrification
Total organic N.	% removal
+ free NH_3	% removal
Oxygen consumed	Quick measure of improvement
Alkalinity	Sludge removed
Total solids	
% Moisture	Ease of drying
Volatile	Degree of digestion
Ash	Degree of digestion
Fertilizer value	
Available N.	Usefulness
Potash	Usefulness
Suspended solids	% wt. x 100 / % vol.
Sludge index	

TABLE III A

RESULTS TO BE EXPECTED AT SEWAGE TREATMENT PLANTS OBSERVATIONS AND TESTS BY OPERATOR

	Raw	Settled	Well Oxidized	Sludge
Appearance	Dirty, soapy, greasy or milky with floating solids. Gray to brown.	Opalescent, with only finely divided solids. Gray to brown.	Clear, with some small solid particles. Colorless to brownish tint.	Activated: Golden brown large flocs settle quickly, clear water between. Dig.: Black or dark gray. Uniform viscous.
Odor	Fresh, slight ammonia odor. Stale, putrid, sour, or rotten-egg odor.	Same as raw, but less defined.	Odorless or earthy.	Act.: Earthy. Dig.: Tarry, inoffensive.
Settleable solids	2 to 20 c.c. per litre.	Tr. - 0.2 c.c. per litre.	Tr. - 0.2 c.c. per litre.	Act.: 5 - 40% Ret.: 50 - 99%
pH	6.0 - 8.0	6.0 - 8.0	6.6 - 7.2	6.8 - 7.8 usually 7.2
Relative stability	½ - 2 hr.	1 - 4 hr.	,10 days 90 - 99+ %	
Sulphides	Fresh: 0 - 2 p.p.m. Stale: ,2 p.p.m.	Slightly more than raw.	None	
Residual chlorine	Varies with sewage and period of contact.			

TABLE 3 B
TESTS BY PLANT CHEMIST

	Raw	Settled	Well Oxidized	Sludge
B. O. D. (5-day)	100-600 p.p.m.	80-300	2- 25	
Suspended solids	100-600 p.p.m.	80-150	2- 50	Activated .10- .40% Ret. act. .40-1.0 %
Total org. N + free NH_3	25- 75 p.p.m.	20- 50	2- 10	
Nitrites	0- 1.5	0- 1.5	0.5- 7.0	
Nitrates	0- 1.2	0- 1.2	0.5-15.0	
Oxygen consumed	50-250 p.p.m.	40-150	5- 70	
Alkalinity	50-450	50-450	40-300	
Total solids	500-2000	400-1200	300-1200	Raw 90 -97 % Digested 5 -19 % Activated 0.15- 1.5%
% moisture				Raw 3 -10 % Digested 90 -95 % Activated 99.5-99.85%
Volatile				Raw 60-80% Digested 40-55% Activated 45-75%
Ash				Raw 20-40% Digested 45-60%
Fertilizer value				Digested 0.8-3.6% Activated 3.0-6.0%
Total N (available)				
Phosphates (P_2O_5)				Digested 0.6-2.0% Activated 1.5-3.0%
Potash (K_2O)				Digested 0.2-0.8% Activated 0.3-0.6%
Grease	15-150 p.p.m.			Digested 5-25%

DISCUSSION OF REINKE'S PAPER BY R. F. GOUDEY

Any paper is worthwhile which helps the operator correlate laboratory findings with his own observations. One can keep close tab on a plant simply by using his eyes, nose, and common sense. The employment of these senses, backed with corroborating laboratory data, leads to efficient operation.

An operator in addition to knowing the characteristics of various types of sewages, sludges, and effluents, needs practice in making simple practical tests. For instance, if he desires to know how badly activated sludge is bulked he can add a little lime to a 1000-c.c. graduate full of aeration or re-aeration liquor and note how quickly the lime clots the sludge, appears to collect in large flocs, and then sharply tumbles down. If he suspects certain wastes as the cause of bulking he should obtain some, mix them with aeration tank liquor in a 2-quart jar, and allow them to settle after 4 to 6 hours aeration.

Intelligent operation means actual proving on an experimental scale of the conclusions reached from observation of plant operation. For instance, he knows that he is carrying a heavy load of solids; the laboratory then tells just how much. There has been some discussion as to the advisability of operating an activated-sludge plant so that the sludge will rise after about 2 hours sedimentation. Quick-rising sludge is apt to be caused by too high a bacterial count, with no other advantages attendant upon it. Sludge at the Griffith Park plant will stay down 3 weeks and longer without rising. The elimination of weeds and use of lime accomplishes this result.

I use laboratory data only to substantiate field findings and, because of the many weaknesses of most of the tests, feel that great care must be used in the interpretation of laboratory results. This is particularly important until proper revision now under way has been made of 'Standard Water Analyses' as applied to sewage analyses. One of the most useless series of tests are the free ammonia, nitrite, and nitrate determinations in connection with a study of the nitrogen cycle. The presence of certain types of bacterial filaments will destroy all nitrites and nitrates completely, and the final effluent may be clearer and better than ever. On the other hand, the final effluent may carry 30 p.p.m. nitrates and appear inferior.

Absence of nitrates by no means is conclusive of poor operation In fact, under certain conditions it is a sign of exceptionally good operation. For this reason the fixing of limits for free ammonia, nitrites, and nitrates, so far as operation of an activated sludge plant, is not as hopeful as formerly appeared. A good field test for nitrites is the orthotolidin method used for the free chlorine test. When nitrites are high ahead of the point of chlorination this method roughly indicates to the operator that filamentous organisms are absent.

The putrescibility test is a rather convenient test to conceal inferiority. Invariably an operator will remove the stopper and allow a visitor to smell it. The act of opening the bottle will add sufficient oxygen to keep the blue color indefinitely.

The question of what reduction in alkalinity in treated sewages over that present in raw sewage is again brought up for discussion. I have carefully analyzed the oxygen consumed and alkalinity reductions in the data contained in Reinke's paper as well as from several thousand analyses from the Griffith Park plant and find absolutely no relationship between those two tests. The alkalinity test by its very nature is simply a measure of acid absorption by sewage samples. The less organic matter in the samples, the less is the acid absorption. In clear waters the alkalinity test gives a measure of the carbonate, bicarbonate, and hydroxyl-ions, but in sewage and sewage effluents the test is not specific. The percentage of oxygen-consumed removed by treatment at Griffith park in reference to that of the water supply is 90%, whereas the corresponding removal of alkalinity is 45%. The ratio of per cent alkalinity removed to oxygen-consumed removed averages 0.5. This value is the same ratio as at Lodi, but there the percentages of alkalinity and oxygen-consumed removed were half that at the Griffith Park plant.

The standard test for carbon dioxide is in reality a test for alkali absorption, just as alkalinity is a test for acid absorption. Both have different stories to tell than is to be inferred from 'standard methods'.

Great care must be taken in interpretation of results. First is the sizing up of physical observation. This should then be followed by a correlation of bacterial, microscopical, and sanitary chemical tests. Finally, the limitations of each source of knowledge must be stepped down to a common-sense basis. Then will the operator receive considerable help from the laboratory.

DISCUSSION OF REINKE'S PAPER BY JANE H. RIDER*

Morris Cohn, of Schenectady, has written, "Fewer determinations carried out with more uniformity is what is needed". We are heartily in accord with this pronouncement, especially as it relates to smaller plants, where the operators not only are unskilled chemists but where they have multitudinous other duties to perform each day. The large plants with trained laboratory personnel are concerned chiefly with standardization of methods, while the problem of the smaller plants is to learn the minimum number of tests necessary to judge plant performance. The variety of these tests is limited, not only by the employee's technical ability, but by the tools the municipal governing body has given him to work with. An 8 by 10-ft. room equipped with two Imhoff cones, a pH test set, and miscellany of old bottles is too often dignified by the name of laboratory.

Certain records are important and should be kept, even at small plants; especially is this necessary for growing towns where new works may be needed in the future. These should include the flow of sewage in m.g.d., the temperature of atmosphere and sewage, and length of time mechanical devices are operated, as well as special comment on plant performance. The cubic feet of screenings re-

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moved should be entered, noting the time of cleaning and disposition of this waste. Sludge digestion records may include the pH of raw sewage and sludge, amount of lime added, temperature of sludge, date and amount of sludge discharge to drying beds, together with a notation of its physical appearance and time elapsing before removal from the beds. Small plants may make only weekly entries of these data.

All plants have some form of sedimentation. The performance of these units can be checked by determining the amount of solids deposited in Imhoff cones after standing 2 hours, if it is not possible to use the more accurate method of determining settleable solids by gooch crucibles. Some operators make the time of settling in the cones the same as the detention period in the tanks. If the volume of solids in the overflow from septic tanks were determined occasionally it would do much to dispel the water-clear myth.

The methylene-blue test for relative stability may be carried on at room temperature and may furnish a fairly dependable index to the quality of effluent from the oxidizing units, if a reliable dye is used. It has not the accuracy of the b.o.d. results, nor is it subject to so many variations in technique. A money-saving modification of the b.o.d. is to incubate the sample in a water bath somewhat deeper than the height of the bottles. This will give results of comparative value if the tap water is 2° plus or minus 20° C. Where trickling filters have been installed, the settleability solids and relative stability of the effluent should be determined. These tests should also be made for the effluent from the secondary clarifier.

Activated-sludge plants demand more continuous supervision and more elaborate bookkeeping. Settleable solids should be determined for primary and secondary settling tanks, and relative stability or the b.o.d. of the final effluent. It is further necessary to record the aeration period, quantities of activated sludge returned and wasted, and power consumed per m.g. treated. A well-equipped laboratory is almost a necessity for economic operation; it is so essential to know the d.o. and b.o.d. of the different steps in this treatment.

When plant influents or effluents are chlorinated the flow in m.g.d. should be recorded, together with the number of pounds of chlorine used each day and the residual chlorine as shown by the orthotolidin test. In making this test a slightly different procedure must be followed than for clear water.

The Johnson modification of the Salle-Reinke test for sulphide is easily made in the field and is valuable to indicate the presence of hydrogen sulphide and other odor-producing gases. We have used this test to show complaining citizens that plant effluent did not contain these roving smells and that odor nuisances causing discomfort might be closer to their doorstep.

Good plant operation is synonymous with plant cleanliness. The public judges performance both by straying odors and the condition of the stream used for final disposal. These advertisements of efficiency or carelessness can only be controlled by meticulous attention to detail, and laboratory tests, simple or complicated, confirm what the operator should observe to a certain extent with his eye and nose.

UNUSUAL CONDITIONS ENCOUNTERED IN CALIFORNIA SANITARY SEWER DESIGN AND CONSTRUCTION

By CHARLES H. LEE*

Unusual conditions are the rule in sewage treatment practice, but in design and construction of sanitary sewers, conditions ordinarily permit of a more or less standardized procedure. This is particularly the case for communities located in valleys or on smooth topography. In towns and cities along the California coast, however, unusual conditions are frequently encountered, and this paper will describe some which have come to my attention.

Inclusion of Stormwater in Sanitary Sewers

Collection and disposal of domestic and industrial sewage has become a universal feature of modern community life, and sanitary sewers are among the first improvements to be provided in a newly-established town or subdivision. Due to the great cost of providing underground drains for stormwater, the latter during the early years of a community is usually allowed to collect in gutters and is discharged into convenient natural channels.

Eventually, in thickly built-up districts where surface drainage collects at times of storm so as to create nuisance or damage by flooding streets and private property, special storm drains are provided. It is not common practice in California, however, to provide combined sewers, or those having capacity sufficient to carry both stormwater and the sanitary sewage originating within the area drained. The outstanding exceptions are San Francisco and the East Bay cities, where peculiar topographic and outlet conditions have quite generally led to the use of combination sanitary and storm sewers.

Conditions which in new communities favor the construction of combined sewers are:

1. Infrequency of excessive rates of rainfall.
2. Extensive areas to be drained, having either poorly developed natural channels or natural channels whose alignment closely corresponds with the desirable alignment for sanitary submains and mains.
3. Short outfall lines to an outlet point for storm water.
4. Land embraced within natural channels valuable for building or street purposes.

In established communities, economies may result from the construction of combined sewers where stormwater drainage has become necessary and relief sewers are needed to overcome surcharging of sanitary sewers at the time of storm.

All of these conditions occur in various portions of San Fran-

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cisco and the East Bay cities and have had an important influence upon sewer planning.

Capacity of Combined Sewers—The larger size of combined sewers and the greater cost make it desirable to give more careful study to problems of design than in the case for sanitary sewers. The most important item to be considered is that of capacity. While there are exceptions, it is generally true that the quantity of sanitary sewage to be handled is so small with respect to stormwater that it is well within the limits of accuracy to which the latter can be computed. Stormwater flow, therefore, controls the capacity of combined sewers. The computation of stormwater flow is one of the most intricate problems of hydraulic engineering. Cities faced with a large program of stormwater drainage are able to give the subject thorough technical study and develop methods adapted to the local conditions, as has been done by the Bureau of Engineering, City of Los Angeles, and the City Engineer in conjunction with the Engineering Commission on Sanitation and Drainage, City of Oakland. Such study is not included in the routine of most municipal engineering offices, however, and the general features of the methods may be of interest.

Various empirical formulas have been used in the past to compute stormwater discharge, but such formulas are of necessity limited to special or local conditions and are not adapted for general uses, as the experience of recent years has too frequently shown. The so-called 'rational' method is now coming into general favor and is used in many large American cities. This is based upon the direct relation between rainfall and runoff, and assumes that the runoff from a given area will be greatest when all parts of the area are contributing at the greatest rate. A lapse of time is required after a storm commences, first to fill depressions and saturate the surface soil, and then for the water to flow from the most distant point in the drainage area. The maximum runoff at any point in a sewer is to be expected from a rainfall of maximum intensity continuing long enough for the water from the farthest point of the drainage area to reach the point.

In application of the method, it is necessary to have local data regarding the intensity of rainfall to be expected for the various times of concentration; the runoff factors for present and probable future types of urban development upon tributary drainage areas, times of concentration from roof to street gutter, through gutter to sewer and through the sewer; and the acreage of drainage areas tributary to storm water inlets. Data of this character are now used as the basis for design of combined sewers in San Francisco, Oakland, Berkeley and other cities.

Rainfall Intensity—Information regarding frequency and intensity of rainfall is of fundamental importance in the application of the rational method. Such data are obtained from automatically recording tipping-bucket rain-gage observations continued for a period of years, and when analyzed may be most conveniently expressed in the form of graphical curves. These curves show the rates of maximum rainfall to be expected during periods of 5 to 120 minutes, or longer,

for storms of greatest intensity to be anticipated within various periods such as 10, 15, 25, 50, and 100 years.

The degree of efficiency of a storm-sewer system is measured by its ability to collect and carry off storm runoff without flooding streets or private property and causing inconvenience or damage. A sewer which functions perfectly for every storm, no matter how severe, might be termed 100% efficient, while one which fails to carry off the water from storms of an intensity to be expected every other year, might be rated at 50%. The determination of efficiency for which a given storm-sewer should be designed is largely a matter of judgment, but consideration is usually given to the following.

1. Economics. There is a certain size beyond which it is more economical in the long run to allow overflow and pay or suffer damages rather than carry the greater interest charges on larger-capacity sewers. The determination of this size involves an estimate of the damage which may result from flooding and the estimated fixed charges for capacities adequate to handle the runoff from the maximum storm to be expected in various periods of years.

2. Legal Responsibility. The courts have generally held that the responsibility of a municipality for damage from overflowing storm sewers is dependent upon the character of the storm. Storms are divided for judicial purposes into ordinary storms, or those which occur frequently; extraordinary storms, or those which may reasonably be expected once in a while; and unprecedented storms, or those which exceed any of record. The usual rule in determining the responsibility of a city is, that if gutters and sewers are of sufficient size to carry off in safety the runoff from ordinary rainfall resulting from storms liable to occur in the region, it is all the law should require.

In practice, sewers are designed of sufficient size to handle runoff from maximum storms of 10 to 25-year frequency. Combined sewers built in the city of Berkeley under the 1928 bond issue were designed for storms of 10-year frequency in the residential areas and 15 years in business and industrial districts.

Grades of Combined Sewers—Another element in the design of combined sewers which must be considered in more detail than for sanitary sewers is that of grade. As an instance may be mentioned the importance of using hydraulic grade instead of invert or flow-line grade in determining capacities. This is of especial importance at sharp grade changes, or where the outlet is at tide water.

A difficult grade problem exists along the western waterfront of Oakland and Berkeley.

The Southern Pacific railroad occupies a right-of-way at the original shore line of San Francisco bay, and the top elevation of all underpass structures is controlled by railroad grade at an elevation but 10 or 12 ft. above mean sea level. Numerous combined sewers which drain the thickly-populated alluvial slopes upon which the cities are built cross the railroad at right angles. Originally, sewer outlets were located at the margin of tidewater a short distance west of the railroad, but with industrial development the tidal flats are being replaced by dredger fills, and in order to reach tidewater, sewers must be extended further west with an almost horizontal flow-line grade. The U. S. bulkhead line, as now established, is more than 1 mi. west

of the original shore line, and the distance to pierhead line exceeds 2 mi.

To discharge stormwater at the bulkhead line with the very limited head available at the railroad crossing would require structures of prohibitive size. A more practical alternative appears to be the utilization of head from the relatively steep alluvial slope east of the railroad by sealing the lower portion of existing gravity-flow sewers so that they will act as pressure lines when discharging storm water. This will necessitate the construction of short collection systems for low-lying areas, and sanitary interceptor lines west of the railroad, the latter delivering sanitary sewage to sumps from which it can be pumped to a tide water outlet at the pierhead line. By the provision of leaping weirs or similar structures in existing sewers, sanitary sewage could normally be discharged into the interceptor lines, but at time of storm would be discharged in greatly diluted condition at the bulkhead line.

Inlets—The efficiency of a combined sewer in carrying off stormwater depends not alone upon having adequate capacity but upon the effectiveness of inlet facilities. The clogging of inlets by trash of various kinds and inadequate capacity resulting in the escape of water —especially when flowing at high velocity in steep gutters—is a frequent cause of trouble. To remedy these conditions and provide a definite basis for inlet design which could be applied to various street conditions, the Storm Drain Division of the City of Los Angeles several years ago undertook an extensive series of investigations. These included experiments with a street model which could be adjusted to various grades and cross-fall and be fitted with grating and side-opening types of inlet. At the lower end of the model, a slab of plastic modeling clay was provided which could be formed to various shapes and permitted actual flow tests to be made upon different types of inlet depressions. The experiments were remarkably successful and resulted in the development of standard plans, which with diagrams and instructions permit the design of inlets of known capacity and high efficiency under almost any improved street condition. All inlets in the city of Los Angeles are now being installed in accordance with this design procedure and several other cities are trying it out.

To insure successful operation, it has been found desirable to have an engineer familiar with the design procedure check the layout and supervise construction, thus insuring accuracy in dimensioning and the shaping of surfaces. The engineers who planned and carried out these investigations have made a very useful contribution to sewer practice and are due great credit.

Influence of Tidal Water

Tidal-water introduces a number of problems into sewer design which are not met with away from the coast. These problems arise from various causes, principally the fluctuation of water level, tidal

currents, salinity of the water, and activity of certain types of marine life.

Effect of Tidal Fluctuation—For sewers whose outlet is near shore line there is the question of proper flow-line elevation. The common practice is to place it at, or just above, mean low tide elevation. This insures complete flushing of the lower end each day and permits inspection. The advantages are sometimes lost, however, where debris collects in the vicinity of the outlet so as to obstruct free flow at low tide.

Runoff from unusually heavy rains in February 1927, after nearly 10 years of light rainfall intensities, brought much gravel and sand into the lower portion of University Ave. combined sewer in Berkeley where it receives the flow of Strawberry creek. This debris was carried through the sewer and deposited on the tidal flats adjacent to the outlet. A high bar was thus formed with ponded water behind it at low tide, submerging the invert 18 in. deep and extending up into the sewer 250 ft. Silt and sludge soon collected in the lower end of the sewer to a depth exceeding 12 in., considerably reducing its capacity and creating a foul condition.

Where sewers discharge into inland tidal waters, storms in conjunction with high tides often produce unexpected conditions. High tide in San Francisco bay, for example, may exceed the predicted level by 18 in. or more at time of great winter flood discharge in the Sacramento and San Joaquin rivers.

At such times local rains in the East Bay region may produce spouting manholes at high tide in low-lying industrial, business, and even residential areas. This occurs both in combined sewers and in sanitary sewers which are temporarily surcharged by surface and ground-water leakage. A strange sight once witnessed by me during a storm at high tide was the lifting of several hundred feet of the flat concrete cover of a box-section outfall sewer where exposed on tidal flats, and discharging under pressure of a 3-in. sheet of water from either side of the sewer between the raised cover and the top of the sidewalls. Conditions such as this, although of very infrequent occurrence, are a possible source of danger to public health and damage to property, as well as an inconvenience. The remedy is costly in an established community. For a new development it might well be given consideration in establishing street grades and elevation of fills in low-lying areas.

Tidal currents in inland waters such as San Francisco bay are of great aid in sewage disposal. The enormous volume of the tidal prism which flows in and out of the Golden gate with each tidal cycle, maintains a normal free-oxygen content in bay water. Sewage discharged into it at points where active tidal currents prevail is immediately diluted and disbursed, and soon rendered innocuous by the presence of free oxygen in the water. Nuisance arising from sewers discharging into San Francisco bay, where found to occur, is usually at points where tidal currents are feeble or absent, such as dead-water areas created by long fills extending out from shore or within inden-

tations of the shore line where water is pocketed. In such locations, settling solids accumulate on the tidal flats and adjacent submerged areas, forming sludge beds in which decomposition proceeds at a slow rate, with production of odor. Floating solids may also be carried back into sloughs at high tide and deposited on flooded marshes as the tide recedes. Such conditions can usually be remedied by extending sewers into an area of more active tidal current.

Marine Life—The teredo and other marine borers have given considerable trouble in San Francisco bay during the past 15 years, their activities extending to the upper reaches and margins of the bay where the degree of salinity has increased as the result of a long series of dry years. Wooden piles previously immune were attacked in a wholesale manner, and losses ran into millions of dollars.

A rather unusual instance of damage occurred on the western waterfront of Oakland. The outfall of the 22nd St. sewer extends diagonally across tidal mud flats for a considerable distance and is supported on wooden piles. At the time of construction these were completely buried in the mud, although the upper portion of the concrete sewer extended above mud line several feet and the top was ordinarily above high tide. Subsequently, a long railroad fill was constructed at right angles to the shore and crossed the sewer so as to isolate a triangular area of tidal land. As the latter dried out there was created a difference of head on either side of the sewer which ultimately blew out openings through the mud under the sewer. These holes finally became enlarged to a size sufficient to equalize the head during each tidal cycle. This action exposed the piling to salt water for a distance of more than 500 ft., in which condition it was attacked by teredo with resulting local settlement of the sewer and such serious cracking that at certain points large holes were opened in the bottom and sides. This experience points to the desirability of protecting wooden pile foundations from marine borers where there is possibility of exposure.

L. A. COUNTY SANITATION DISTRICT'S PLANT

(Continued from page 32)

similar conditions oxidize into a brown dust and do not last. However, for exposure to raw sewage or moist conditions in the absence of sunlight, the reverse is true and the bituminous paint stands up best. Aluminum paint lasts very well for most services. Its use where exposed to sunlight results in an insufferable glare, and at the other end of the scale it is not as lasting as the bituminous paints when in direct contact with raw sewage. For building paint around the plant, ordinary good-grade lead paint is the most economical. The economical selection is not one of selecting one good paint, but rather the selection of the correct paint for the purpose at hand.

A SANITARY CORRESPONDENCE

Steve to Al—As One 'Sewer Rat' to Another

By LEON B. REYNOLDS*

Rose Arbor, Calif.
May 13, 1932

Dear Al:

I hopes you aint a goin to feel that I'm too offishus writin to you, but I rekon this plant uv mine aint a workin too hot. You know since you stopped here to see my plant a while back, I bin doin some thinkin about it. It don't seem as if it ought to need much lookin after, but you kind uv give me an idee that I could help it some if I knew how.

Course you don't know much about me, havin seen me only onct, so maybe I better tell you how I got this here job. My brother Jim, he's lived in this here town all his life and I spect he noze every man, woman an chile here. Two years ago he up and decided he ought to be the big gun uv this here town so he sez to himself "The thing this old town needs to put it on the map is a real sooer system." So he run for mare on that there platform an tole the folks how it'd give em lots uv work buildin it an wouldn't cost much, being as the bonds could run forty years.

Well, he wun, an the sooers were finisht a year ago an the ingineer what planned em said some bozo had ought to be hired to run em, so Jim he put in a good word for me allowin as how I was a good worker an I got the darn job. So here I bin for the last year tryin to run this here sistem. I wuz goin to tell you more about my sooers but I'll do this next time cause I'm pretty tired; hopin you is the same.

Yours,
Steve

P. S. Say, you sez somethin about a meetin where fellers like me can learn something about how to run their sooers; please give me more info.

Jonesville, California
May 17, 1932

Dear Mr. Brown:

I was glad to hear from you and to learn some of the history of your sewer system. You have quite a job on your hands to run such a system properly, and my experience is that I keep learning more about it and finding out about new methods of operating. By the way, there is to be a meeting of the California Sewage Works Association next fall in the southern part of the state, and most cities pay the expenses of their operators to attend this meeting so they can learn to run their plants better. Probably your city would send you. Hoping to see you there,

Yours,
Al

Rose Arbor, Calif.
May 27, 1932

Dear Al:

I sure wuz glad to git your letter an I showed it to my brother an he rekoned it might be a good thing so he tuk it up with the consil an they said it'd cost more'n it wuz worth an that they needed all their money to fix the roads. So I guess you wont see me there. I'm sorry cause I like to git away from home and would have a hell uv a good time down there I know. While I'm writing, maybe you'd like to know more about our sooers.

When Jim was elected lots uv ingineers come to see him about the sooers he had run on to git elected, an they all wanted the consil to sign a paper agreein to

* Professor of Sanitary and Hydraulic Engineering, Stanford University.

let em make a report on what the sooers would cost. After a while one came along who wuz willin to make a repore fer nothin, seein as how they would uv course hire him to do the rest uv the work later. So in a few days he come back with a book with lether cuvers an drawins an all wrote on a typewriter an he sez the sooers an disposal plant would cose $42,659.71. Course the consil knowed nothin about it but the report wuz pritty lookin an they allowed as how it wuz probably O. K., but in a few days another feller dropped in an he sez that he could put in the hull plant fer $5000 less by usin some other kind uv pipe an stuff in the joints an not putting the pipe so deep. So the consil hired the last feller an uv course the firstone didn't like it very well an kicked up quite a muss but the savin looked pretty big to the consil. So they had a election an voted the money which we don't have to pay fer forty years an by that time you an I an Jim an the consil will be gone so why worry about our town's trubbles when I have lots uv trubble uv my own, one of which is fomin. Hopin you are the same,

Yours,
Steve.

P. S. A Bored of Helth feller wuz here the other day an he sez I ought to find the ph in my tanks. Not wantin to seem dum which I aint I said uh-huh; but say, what the hell is it anyway? An say, jest call me Steve, I ain't used to that mister stuff.

Jonesville, California
June 2, 1932

Dear Steve:

Thank you for your letter describing your sewer system. Your town has found out as usual that cheap engineering is likely to be poor engineering and that the quality of a report does not deepnd upon the binding. Write me more about your sewer sometime.

Your inquiry about the pH is a natural one. You see I had the advantage of you and learned all about it in school. It tells the degree of acid or alkaline condition in your tanks. At the meeting of the C.S.W.A. the method of making the test will be demonstrated, and not being difficult, can be learned by anybody. Too bad you can't go to the meeting; some day I'll drive over and show you the test anyway.

Yours,
Al

Rose Arbor, Calif.
June 30, 1932

Dear Al:

I'm afraid there's no hope uv my going to your meetin cause I showed your letter to the butcher what heads the sooer committy uv the consil an he sez to keep my shirt on an not git high-fallutin idees about our plant. He sez the main thing is to take the ph out of phew an git rid uv the stink in my tanks or the consil'll have to hire a new sooperintendent. So that's that.

I wuz going to tell you in my last more about the way our sooers wuz built. The man what wuz given the job wuz spicioned to be a slicker but the engineer sez his man would watch him like a hawk an see that he done his job O. K. The ingineer's man wuz a young feller just out uv school but he sure knowed his stuff an made em lay that pipe straight as a string. The pipe did seem pritty close to the surfis but he sez it wuz that way on the plan, an the Bored of Helth had O.K.ed the plan so it must be O.K.

You remember I tole you that the second ingineer, the one what didn't make the first report, sez he could build the sooers fer less money than the first ingineer. Well, what with extras an more rock an so on, the consil wuz supprized to find out that the money wuz gone an the sooers not all laid so they had to cut out some lines, but none uv the concilmen lived there. Even if a few citizens ain't got sooers, I got more than enuf sooage at the tanks.

We never seen that ingineer since the sooers wuz tested an if you see 'im at your meeting, tell 'im we will have to build a perfoom factory to offset the sooage

plant. My plant sure gives me the jitters, hopin you are the same.

Yours,
Steve

P. S. I've been wonderin who all goes to that their associashun uv yours, so's I could tell the head uv my sooer committy.

Jonesville, California
July 4, 1932

Dear Steve:

I am glad you wrote me more about your sewer system. Not always is the best engineer the one who can put in the cheapest system, and maybe he didn't get enough fee from your town to justify his giving you help in the operation of the plant.

Our association membership includes plant operators, city engineers, material salesmen, designing engineers, college professors, and anyone interested in sewerage and sewage disposal, such as heads of sewer committees. You would be surprised to know how human even the college professors are, once you get to know them. The head of your sewer committee and you both ought to be members. Practically every town of any importance in the state is represented in the membership.

Yours,
Al

Rose Arbor, Calif.
July 25, 1932

Dear Al:

Your letter sure wuz the hot stuff an when I showed it to the head uv my sooer committy he sez to me sez he that mebbe he an I had ought to belong cause we want our town to be knowed as being among the up an comin places in this state. You know our consil is a runnin a contist fer a sootable slowgun fer our town, a slowgun that would shoot an idee uv the booty an classiness of this here town into the brains uv the toorists. I ain't losin any sleep consarnin the town's slowgun, but I bin tryin to make up one fer my plan by thinkin of slowguns I've saw. One what is suggestiv if idees is used by a sope an perfoom maker, to wit "If you don't use our sope, fer heaven's sake use our perfoom." Or the cigarette slowgun might be changed into "Not a stink in a tankful."

I guess I never tole you about the ingineer what wanted so bad to build us one uv his sooper servis plants—no sludge, no smell, clear effloont, no soopervision—say, when I think of that last I sure wish we had sich a plant, life would be a boll of cherries instead uv razzberries. But all the other ingineers tole the consil "There aint no sich thing," so they didn't take him up on it.

Oh my, oh my, in my case its jist one darn thing after another, an sometimes at the same time. Jist when I've got the sludge learned to stay down, up she comes bent on fomin all over the landscape. I rekon mebbe the ph's has somethin to do with it or mebbe the bugs that the Bored of Helth man talked about. An say, he sez sprayin with water would be easier than rakin, an tweed you an me it sure does give me that tired feeling. But I ain't got no water here so I has to use my mussels. You know the young feller what soopervised buildin this here plant tole the consil they had ought to run a water pipe to the plant but the consil din't see no use in it. Yes, an effluent don't look so hot neither an the crick down below aint got much water besides the sooage so the crick aint so hot neither. So to myself I often sez that this job aint what it wuz cracked up to me. But what's the use of gettin all het up about it.

By the way, the chairman of our sooer committy sez probly it'd cost too much fer fellers like we all to jine your associashun. An besides I have a sneekin spicion he's scared of the college profs. I'm sure tired uv runnin a sooer plant, hopin you are the same.

Yours,
Steve.

P. S. A Feller by the name of Alek wuz here a few days ago an told me that

cloreen wuz good to stop fomin an the stink. I ast my brother Jim about it an he sez the only thing he knew cloreen wuz good fer wuz to make blonds fer the movies. Anyway there's plenty uv stink in Hollywood sometimes even if they do use cloreen.

Jonesville, California
July 30, 1932

Dear Steve:

Your letter telling about your troubles was very interesting to me and I believe that most of them could be eliminated. Come and see my plant sometime; of course it isn't the same kind as yours but you might be interested in it anyway. Different types of plants are suitable for different conditions.

I don't believe that the membership fee would stand in the way of your joining the Association because it is only two dollars a year. Besides the meetings you would receive five books a year giving lots of information about your work. And say, tell your sewer committee chairman that he wouldn't be able to tell the college profs from the rest of the sewer rats.

Yours,
Al

Rose Arbor, Calif.
August 11, 1932

Dear Al:

Hell is sure poppin down here. You see the folks what live along the crick down below our plant is all riled up about the smell which they say does not even faintly resembul roses. They passed the word around I understan fer a meetin, the which some uv em called a indignashun meeting, an I've been tole that the langwidge used wuz sizzling hot. I reckon the consil an me got ours. Some folks even five miles down the crick hotfooted it to the meeting to cuss the plant an the city an the consil. They sez all the fish wuz ded an the frogs had to come out on the bank to puke after swimmin in the crick.

Well, after cussin an discussin everythin in general an some things in pertickler some one sez why not write the Bored of Health to send us a Bored expert down cause they wuz bored uv the stink. So they appointed U. B. Dam what had been speshally cawstick in his remarks, to write to the Bored an ask em why they had O.K.ed sich a worthless systim an to come down an tell the city where to head in or else the aforesaid damaged parties would have to adopt legal or explosiv mesures.

So you see we are in a peck of trubble an I am planing some salivas an spittoonias around the plant to make it look an smell pritty before the Bored uv Helth expert comes. The consul is plenty worked up about the sittooashun an is havin secret seshuns a plenty an is a visitin my plant a plenty which is somethin new fer em to do. Corse every one is a givin me pinters on runnin the plant an if I follered all uv em, nobody knows how messed up it would be. I jest agrees with all uv em an then goes ahed as I pleze. But it aint gittin much better's far as I can see.

But say, the head uv the sooer committy wuz sure supprized about the size uv the membership fee, seein as how he expected it to be about the same as that uv the Leage uv Cities. He is going to ask the consil fer money to pay both uv our fees an expenses an then he sez he'll drive his Model T to haul us an it won't cost much. An he thinks on account uv how the consil is so het up about the plant that they may loosen up.

I hev thought an writ so much about our trubbles that I am nuts, hopin you is the same.

Yours,
Steve

Jonesville, California
August 15, 1932

Dear Steve:

I am sorry to hear that you are having so much trouble with your plant but I am sure you will find the sanitary engineers of the Board of Health very fair and very helpful, and they will no doubt assist you in getting your plant in shape so that it will not be a nuisance to the neighbors. It's too bad that the Board can't have enough funds to provide the personnel necessary to make more frequent visits to plants.

No loss without some small gain at least, they say, and I hope that your council sees fit to send you to the meeting of the Association where I am sure you will learn a lot, the same as the rest of us do.

Yours,
Al

Rose Arbor, Calif.
September 7, 1932

Dear Al:

The Bored uv Helth boys his bin here an I thot you had ought to know about it. I aint tellin you their names, they wuz tuf ones to remember, but you may know em when I say one wuz tall an lite-haired an soft-spoken an the other wuz shorter an blacker an more outspoken. Beleeve me, they sure got busy and drew out a lot uv sludge I had tried my durndest to keep down an changed the gates so that the sooage went in another direction an said somethin about its not being right to go down thru one slot an up thru the other an that this here tank wasn't no skeptic tank. Mebbe I forgot to tell you one of the concilmen insisted I try it that way. They sez I had ought to have the water pipe down here an had ought to have more tools an testin contrapshuns. An they tol the neighbors that such plants sometimes give trubble the fust year before they got down to bizness an that they should keep their shirts on an that we would have the plant workin fine soon. I heered one tell the other somethin about more buffer strip bein needed, whatever that is, and the other tellin the first one somethin about handlin the cremery wastes. And they promised to have another feller come down an stay a while with me fer company an to show me some triks.

And say, Al, they tole the consil that one of the best waze they could spend a few bucks would be to send me an the head of the sooer committy to that meetin of yours an the consil said O.K. they would try anythin once, being desperit as they is. So we is planning to go an I hev to thank you for what you hev done. Those hard-fisted old codgers on the consil is a tryin to redooce taxes without a carin much how; fer a while they wuz sayin that sooers ought to run theirselves, but not since our trubble. I is sure busy nowadays, hopin you is the same.

Yours,
Steve

Jonesville, California
September 12, 1932

Dear Steve:

Hurrah for you. I am surely glad to hear that you and the chairman of your sewer committee are going to the meeting of the Association. I will be on the lookout for you there and will see that you meet some of the other operators, especially those having plants like yours. You see that is the only reason for such an Association, so that we can help each other. And be sure to get there in time to take the inspection trip.

Yours,
Al

Rose Arbor, Calif.
September 21, 1932

Dear Al:

Jest a line to tell you that me an the head uv my sooer committy is a leavin next Sunday fer the meetin an will see you there. U. B. Dam wuz up at the plant

today an sez they is fixin up the papers in the damage soot so if we don't git this plant going better right soon they will be filed. But fer some rezon I is feelin hopeful. I'll be seein you soon.

Yours,
Steve

Rose Arbor, Calif.
Oct. 1, 1932

Dear Al:

Well, Al, I an my buddy arrove home yesterday an say, we sure has got the worth uv our monie at the meetin; come to think uv it, the consil is a payin fer it insted of we fellers. And we sure did have a bully time. We never spected so many bozos wuz intrested in sooers an sooage, includin the college profs. Us two sure do thank you fer interducin us to so many fellers. An say, your, or rather our now, secretary is sure onto his job; why we had hardly arrove before he wuz askin us to jine an fork over our two bucks, which little thing we did pronto, an he give us cards showin we is members, an he sez that Rose Arbor is sure on the map now an we is a going to do more fer the town than a mere slowgun can.

Hooray for the C. S. W. A.! An did we lern a lot! A feller, I fergit what his name wuz, sez his plant wuz like ours an that he hasn't been able to learn his sluge to say down yet either; he give us a invite to come see his plant which we are a goin to do bimeby. An one uv the college profs sez he wuz a goin to bring his stoodents to see my plant an whispered to one uv em somethin about Tracy.

An, believe it or not I sez to the consil, there wuz a lady from Arizony on the program, an how a swell-lookin jane like her can be intrested in sooage gits my goat. An she brung the hull mess uv Fenix sooer rats with her which shows her infloonce in that there commoonity. An more'n that I wuz tole that two other dames is members an that one uv em most always goes to the meetins an insists on seein everythin an doin everythin what the rest uv em sees an dies, but I hears she is the secretary uv a saneetary deestrick what may bild a plant some day and she is a goin to be wise on what they git. An say, if we had uv done the same we would uv bin better off now.

An say, that feller from San Anselmo, wuz his name Perry, sure did tell me a lot uv things about his town an his plant an his deestrick an how his sooers wuz bilt an how he gits the monie an so on, an he sez I had ought to spend a day with him soon an see it all, the which I am a going to do.

An, Al, that boy Gowdy sure does know his stuff an how, an I didn't hear nobody at the meetin what wuz quite sos ure uv his stuff. Sluge had ought to be his middle name, but between you an me I wonder whether he ever had any such ornery sluge as mine, mebbe the L. A. sluge is better traned. But anyway he sure talks convincinly. An say, did you see how that sluge went down when he added that cathartic milk follered by sand? That sure gives me a idee.

I sure wish I could remember the name us that feller, it wuz somethin like Steve, what thot somethin might be done with common clay in sooage work; well if clay is good fer anythin I sure got lots uv it aroun my plant an it had ought to be good fer somethin an not cause only trubble stickin up my shoes an trackin over the walks. So I'll be intrested in findin out how to use it usefully. That tall feller named Yawn didn't seem to allow as how the idee wuz so hot tho. An say, Steve sure did have that sluge runnin circles aroun itself, seems like it would git dizzy.

Well, Al, I sure is greatful to you fer all you has done an I had ought to do somethin fer you. It is sure your fault that we have went to the meetin an the fellers there sure lerned us a lot the which we will not fergit an we would never have went if it had not uv been fer you. I is sure tired an worn out but happy. Hopin you are the same,

Yours,
Steve

P. S. I'm sure goin to make that sluge do tricks now—I lerned the A B C's uv sooage at the meetin an I'll find out the ph uv the sooage—Mebbe I'll shoot it with cloreen if it still stinks too much, blond or no blond.

DISCUSSION OF GOUDEY'S PAPER†

By WM. GAVIN TAYLOR*

The author, in his paper, has furnished a comprehensive and valuable resume of current practice in the disposal of sewage sludge, and has furnished brief summaries of his personal studies and investigation of sludge disposal. Some of the present-day trends of research in the study of sludge disposal methods are also indicated. That great improvement in sludge disposal as commonly practiced is imperative, is self evident to thoughtful sewage workers. Improvement is in sight. Revenue from sale of stabilized dried sludge may offer a promising return sufficient to more than defray its cost in certain localities and, under favorable economic circumstances, when placed on the market as a fertilizer base or a conditional fertilizer adapted to specific crops, or as humus material. But, demand and recovery values vary widely with seasonal fluctuations and commodity prices, as does the price of grease which may also be a by-product of sewage treatment.

Effective utilization of sewage sludges as a fertilizing material is largely dependent upon delicate balance of available markets and supply of the product. Market demand and selling price are variables—sludge production is constant. The instances where a constant and dependable demand for sludge, at a price at least sufficient to pay for the cost of preparation and delivery, are rare: In large metropolitan areas the market for sewage sludge is usually restricted and distant. In farming areas where sludge might be utilized to advantage, the production is normally low. In any case long-term contracts for sludge delivery are attendant with formidable risks to both parties.

Only a few sewage works in the United States can show a profitable return for more than limited periods of sludge sale. The very nature of efficient sewage disposal practice requires that there be no stocking of supplies pending favorable markets. Sludge should be removed immediately and constantly. Neither season nor the commodity price-index should proporly delay disposal. The withholding of sludge materials and sludge fertilizer in storage awaiting a turn of the season or an advance in the price is a speculative venture which should not be generally assumed by sewage treatment works. Avoidance of nuisance and the sanitary disposal of the sewage material are the primal objectives. Accumulation and storage of sludge, during adverse or low price periods, adds seriously to the capital and operating cost of the works. Only a dependable price, a constantly guaranteed market, and favorable conditions justify a municipality entering into the fertilizer business.

To date, private enterprise has been loathe to engage in the business of recovering values from sewage sludge, though opportunities for privately financed experimentation in this field have existed for

† 'New Thoughts in Sludge Digestion and Disposal', by R. F. Goudey. Read at Yosemite Spring Conference and printed in Sewage Works Journal, Vol. IV, No. 4.

* Consulting Engineer, Newark, N. J. (by letter).

years. Tens of thousands of tons of sewage sludge are available monthly and could be had for the taking, gratis. In the metropolitan area adjacent to New York, large quantities of sewage sludge are wasted daily, by transport to and disposal by discharge into the open ocean. These materials could be obtained cost-free by any responsible party.

Major sewage works along the Atlantic seaboard still find greatest financial advantage in disposing of finely-divided sewage sludge by discharge into the high seas. The cost of disposing of raw sludge from large plants approximates 10c per capita per year. This is a very low cost, and one which offers little latitude for speculative venture in the manufacture of fertilizers or the employment of civil-service labor, if dollar costs are to be the criterion. Any treatment of sludge through digestion or reduction of water content will tend to increase the total cost of sludge disposal over the cost of disposal of raw sludge through sea dumping, as currently conducted by favorablly located large metropolitan sewage works.

The need for an assured market is even more serious for the smaller treatment works contemplating recovery of fertilizing content. Expenditure of public funds for additional works and the required increase in operating force converts a public necessity into a business venture. Public funds may justifiably be devoted to the sale of a public utility, but there seems no justification for small communities engaging in competitive sale of what is—at least in the present state of development—a privately produced and privately consumed product, namely fertilizers. After the risk of development of both product and market has been eliminated, then the manufacture and sale of fertilizers may be considered as a public utility.

Even with a guarantee of income sufficient to offset the cost of production, sewage works should be kept simple in operation, free from elaborate industrial methods, and free from the necessity for employment of highly skilled industrial workers. Public servants, particularly sewage works operators, are not retained for profit-making abilities. The sanitary disposal of the sewage and the constant maintenance of proper efficiencies is more important than money return, and as a goal should not be lost sight of in contemplating a possible profit. Introduction of sludge processing, with the struggle for profits, may tend to remove the goal entirely. Introduction of sludge recovery methods, under present conditions seems justified only by specially favored large cities which are situated near a favorable market.

Is it not a better public policy to allow private enterprise to develop proper industrial processes for the manufacture of fertilizers and other by-products from sewage sludge and provide for distribution through established trade organizations? During the period of development, the sale of raw sludge to a private industry for processing is likely to result in greater public profit than through the conduct of municipal operations.

The ideal procedure for treating sewage and for disposing of the

solids and sludge therefrom, it seems to me, is that which receives the sewage in fresh condition and effects the production of a clear, colorless, stable and suitable effluent, and which disposes of all solids and sludge materials in a sanitary manner—all within the shortest space of time. Under this ideal the time required for treatment of sewage and disposal of sludge should be a matter of minutes, and not days and weeks as at present. Disposal of solids and sludge by the current biological processes, with digestion under controlled temperature conditions, pumping, drying, and removal of sludge for final disposal, to make no mention of special processing for fertilizer purposes, requires weeks of performance. To develop methods for the final and sanitary disposal of sludge, within a time limit of minutes or at most a few hours, we must turn from biological processes, with the necessary controlled temperatures, gas formation, putrefaction, and other phases of so-called digestion of sewage solids and sludge, to mechanical processes, or to a combination of chemical and mechanical processes.

Recent developments in mechanical processes and research in the preliminary conditioning of sewage sludge are making it practicable to consider the dewatering of sludge, and formation of dry solids for incineration continuously and as produced and withdrawn from screens and sedimentation tanks. This dewatering and continuous production of a dry sludge cake may be accomplished by means of mechanical vacuum filtration as I have cited in reference to the successful use of a Wright vacuum filter.

Vacuum filtration is adaptable to a wide variety of uses in sewage works. Sludges of a great variety may be dewatered and incinerated: fresh sludge from sedimentation basins, sludges in fresh or septic state, digested sludge, activated sludge, and other types of sludge and sewage solids. Sludges of certain origin require a preliminary conditioning prior to filtration, which can be adjusted to meet circumstances and physical conditions of the specific sludge. The advantages of mechanical vacuum filtration of sewage sludge are many: the time interval in the process is very short; the sludge is continuously removed; there is no biological action; with a fresh sludge there can be no odors; every phase is under mechanical control; dried sludge cake formation is continuous; incineration of the sludge cake may be accomplished individually or in conjunction with municipal refuse and garbage; every requirement of modern sanitation is met; and the cost of the ultimate disposal of the sludge materials is indeed reasonable.

Mechanical vacuum filters have profitably a still larger field in sewage treatment than filtering and drying solids and sludge preparatory to final disposal by incineration. One field of usefulness would be in an activated sludge type of sewage treatment works wherein vacuum filters are adaptable for the removal of a very large part of the suspended organic load from the effluent of an existing primary settling tank prior to activation. Vacuum filtration may even supplant primary settling tanks altogether. Under unusual demands for

an effluent of extreme freedom from suspended solids, vacuum filtration is adaptable for removal of finely divided suspended solids in effluents from aeration tanks or trickling filters, and for showing a fifiltrate for final discharge containing perhaps not more than 1 p.p.m. of suspended solids.

The field of adaptation and for research and development seem limitless, and with assurance that an outstanding accomplishment has already been achieved, with greater promise for the future.

DISCUSSION OF HYDE'S PAPER†

By PAUL J. BEARD*

Professor Hyde has covered the little there is known concerning thermophilic digestion so adequately, and emphasized the essential points so clearly that he has really left little room for discussion. The paper places before us an exceedingly interesting and potentially important bit of material. It represents a new trend of thought, with enormous possibilities behind it. Just how many of these possibilities may be realized we cannot say at present, but new territory is opened up that demands exploration.

We have confronting us again a biological problem, a problem dealing with living things which have had the reputation of being erratic, capricious, and temperamental. However, in considering the group of organisms known as bacteria, that viewpoint is not quite fair. Bacterial temperament is merely a reflection of our ignorance of bacteriology. I fully believe that as we become more adequately informed we are going to find the bacterium a cheap, efficient, and reliable workman. Our need, then, is for more information so that we may cater to bacterial demands, so that we may control conditions in such a manner as to direct the work of desirable types along the lines of maximum efficiency and reduce to a minimum the activities of undesirable groups. For every type of material, and probably for every set of conditions ordinarily found in nature, we can find some bacterium, group, or succession of bacterial groups that can attack and destroy that material, and if the conditions be properly controlled, do it in a relatively inoffensive manner.

Among the conditions intimately related to bacterial control is that of temperature. We may roughly classify bacteria according to the temperature at which they thrive best. The psycrophiles which grow at ice-box temperatures, the mesophiles which thrive at body temperatures (which includes our disease-producing organisms) and thermophiles, which function best at temperatures considably above that of the body. No definite temperature line of demarkation can be drawn

† 'Digestion of Garbage in Beccari Cells, with Analogies to Sludge Digestion Problems', by Charles Gilman Hyde. Read at Yosemite Spring Conference. See paper by Hyde in Sewage Works Journal, Vol. IV, No. 6.

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between these groups. The classification simply refers to the temperature of greatest growth-efficiency. In fact, there are many groups that have the ability to function quite noticeably under temperatures quite far removed from their optimum. These types we designate as facultative. The term facultative is not confined to temperature relationships, but is applied also to other sets of conditions.

Less is probably known of the thermophilic groups than of the others, yet as living reagents they are important to consider. It is known that chemical reactions are governed by temperature; the higher the temperature, the faster the reaction takes place. This information is concisely stated in the generalization that "every time the temperature is raisd 10° C. the rate of the reaction is doubled." In other words, a given reaction should proceed twice as fast at 30° C., and twice as fast at 40° as at 30°. Bacteria within limits operate undre this law, as is natural, since they perform or bring about chemical reactions. In fact, all life is a series of chemical reactions, and all are governed by temperature, and in case of the allegedly higher organisms such as ourselves, nature has developed a sort of a thermostat control so that these reaction rates do not vary perceptibly.

The degredation of waste materials to stable and inoffensive compounds is, of course, a chemical phenomenon. If you care to examine data on thermophilic digestion of sludge you will find an interesting apparent confirmation of the operation of this temperature law.

Now let us analyze this thermophilic group. In it we find a considerable number of sub-groups. We find aerobes, organisms that must have air in order to grow, and also anaerobes, which cannot perform at all in the presence of air. In addition, we find facultative organisms adapted to function under either condition, provided certain other conditions are fulfilled. We find spore-forming organisms and non-spore-forming types.

The sporeformers, as most of you probably understand, are those creatures that have the ability to enter into a resistant resting stage when conditions are not to their liking. Much as a turtle can withdraw into its shell in time of danger, so the sporeformer envelops itself in a protective coating that insulates it quite effectively from outside influences. In the spore state, they may survive depletion of food supply, many times the normal killing dose of disinfectants, and relatively enormous increases or decreases in temperature. Immersion in liquid air has failed to kill them in this condition, and I knew some personally that after 7 hours of boiling just poked their heads over the rim of the kettle and grinned at me. There are records of spores that have remained alive after nearly a hundred years in dry dust. In this condition they are quite comparable to plant seeds: they do not grow or function appreciably, but do retain the ability to function when the proper conditions are restored.

Still another important and little-studied group are the thermogenic thermophiles. These are organisms that by virtue of the chemical changes they bring about release energy in the form of heat. They so raise the temperature of their environment—an im-

portant economic difference from other types which require the environment to be artificially heated in order for them to function. Study of this group may possibly in time and in part answer some of the economic objections to thermophilic processes.

The various thermophilic groups are quite widely distributed through nature; in hot springs, in the spore state in soils, and in both the spore and growing state in the feces of birds and warm-blooded animals.

With this rather sketchy outline in mind I believe we compare a little more critically thermophilic and mesophilic digestion, as well as analyze the similarities and differences between thermophilic digestion of sewage sludge and of garbage. Comparing the first two processes, i. e., thermo- and mesophilic, the outstanding difference is that of digestion time, of course. The data there, as I previously indicated, are for a rough experiment in nice agreement with the reaction-temperature rule. Thus at 60° to 70° F. the digestion time may be 60 to 90 days; at around 80° F. it is reduced to 30 to 40 days; in the neighborhood of 90° F. from 15 to 20 days; and, at temperatures around 120° to 140° F., from 1 to 10 days. This decrease, of course, indicates a possible great reduction in plant investment. The end products in both cases are much the same; both deliver a stable, non-putrescible humus and quite large amounts of gas of high calorific value.

It is suggested that the humus, since it contains somewhere between 2 and 3% nitrogen, may have value as a fertilizer. I am not so sure that this percentage is economically significant. Certainly not without more information as to the availability of that nitrogen for plant use, which is of more concern than the mere amount of nitrogen present. The gas, in case of thermophilic digestion of sludge, is supposed to be used to heat the sludge so that bacteria can grow faster and consequently reduce the sludge more quickly. This brings us to an interesting difference between the processes of sewage and garbage digestion, in that in the last-named thermogenic thermophiles operate to raise the temperature of their environment to the required point, without the necessity for external heat application. This phenomenon has not been noted to any appreciable extent so far as I know in sludge-digestion experiments, though why is not just clear. Possibly it may be related to the physical state and moisture content of the material.

A further significant difference between garbage and sludge digestion is that of time, i. e., 30 to 40 days for garbage as compared with considerably less than half that for sludge at the same temperature. This again may reflect the difference before noted, that of physical state. In the case of sludge we have a rather finely-divided material, relatively free from very large particles, with a consequently greater surfac open to bacterial attack. In addition, there is a higher moisture content. These factors operating to develop a quick, uniform seeding of organisms over a much greater surface might be expected to make a vast difference in degradation time. Certainly we cannot

expect the bacterium to work on a particle until it gets to it. Rapid distribution insures this condition.

There is another plausible factor to consider in that in the garbage cell the thermogenic organisms, which must be relatively few in numbers at the start, must have time to develop a sufficiently large population to raise the temperature so that the nonthermogenic thermophiles can begin to function as assistants. In sludge digestion the temperature is applied externally and relatively speedily, so that this lag is not evident. It might form an interesting experiment to treat a well-seeded batch of garbage by the thermophilic sludge-digestion process. As to the nature of the gases and of the products of liquefaction in the Beccari process we must remain silent. As Hyde has stated, little if any work has been done along these lines. They offer an interesting path of research.

As I stated in the beginning, these endeavors represent an advance into new territory. It is entirely possible that, given the information necessary to control these processes in the laboratory, they might not be applicable to field conditions. However, no information gained is ever wasted; eventually everything learned is used. The business of the laboratory is to be visionary and ahead of the present field of practical endeavor. Without that attitude we cannot have progress. The thing that is extravagantly impossible or economically unfeasible today, is as likely as not to be the commonplace routine of tomorrow.

1932 SAN DIEGO FALL MEETING PAPERS

Published in the Journal of the National Federation of Sewage Works Associations and not re-published in the current C.S.W.A. Journal:

'Chemical Sewage Purification at Palo Alto', by Ralph A. Stevenson, research engineer, Great Western Electro-Chemical Co., Pittsburg, California. Sewage Works Journal, Vol. V, No. 1, January 1933, p. 53-57. (Also see Western Construction News & Highways Builder, November 10, 1932, issue, p. 635-637.)

'Discussion of Stevenson's Paper', by Paul J. Beard, assistant professor of sanitary sciences, Stanford University, California. Sewage Works Journal, Vol. V, No. 1, January 1933, p. 58.

'Discussion of Stevenson's Paper', by Harvey O. Banks, sanitary engineer, Palo Alto. Sewage Works Journal, Vol. V, No. 1, January 1933, p. 58-60.

Published in Water Works & Sewerage, Chicago, and not re-published in the current C.S.W.A. Journal:

'Control of Anerobic Decomposition in Sewage Transportation', by Fred D. Bowlus, resident engineer, and A. Perry Banta, assistant engineer, Los Angeles County Sanitation Districts. Water Works & Sewerage, November 1932, p. 369.

OPERATING EXPERIENCES AT PHOENIX, ARIZONA, ACTIVATED SLUDGE PLANT

By D. TRAVAINI*

A bond issue was passed for a new sewage treatment plant at Phoenix following numerous complaints from the U. S. Indian Service that water diverted from Salt river for irrigation was grossly polluted, and because of lawsuits threatened by the farmers asking relief from odor nuisances. These country folk had a just complaint, living, as they did, within range of the hydrogen-sulphide gas generated in the bubbling ditch used to carry away the effluent from two badly overloaded septic tanks built several decades ago. This situation made it necessary to design a plant that would produce a stable effluent with a minimum of odors. Acting on the recommendations of C. C. Kennedy, associate consulting engineer, and W. J. Jamieson, then city engineer, the city of Phoenix in July 1931 started construction of an activated sludge plant, with covered separate sludge digestion tanks.

A brief description of the plant is given to clarify the details of operation. A 54-in. reinforced concrete pipe, tiled with vitrified clay from below the flow line to the crown, delivers sewage to a diversion chamber, hexagonal in plan, which connects with the screen house and also provides means to bypass the plant. A bar screen, set at an angle of 30 deg. from vertical with 2 by ¼-in. galvanized steel bars spaced with 1-in. clearance, is automatically mechanically cleaned by a Dorr mechanism. Screenings are collected in steel hoppers and from there are mechanically lifted into a truck. The screened sewage is measured by a venturi flume, connected to a Brown recording meter in the power-house, before entering a Dorr clarifier 86 ft. square and 10 ft. deep from the flow line to the intersection of the vertical wall and hopper bottom.

The clarified sewage is conducted to the aeration field, which consists of five aerators 330 by 27 by 14 ft. deep from the flow line to the bottom of the tank, and a reaerator of similar design. Each aerator and the reaerator has 260 filtros tile and two Imhoff-Dorrco paddles, which extend the full length of the tank and rotate against the air stream. The sewage enters the aerators through submerged rectangular sluice gates connected with a conduit carrying the effluent from the preliminary clarifier. Reaerated sludge enters over weirs from the activated sludge channel, which is placed directly above the conduit carrying the clarified sewage. A 16-in. line is also provided, so that sludge may be returned to the sludge channel without reaeration if desired.

The mixed liquor from the aerators is discharged over weirs into a channel connecting with the secondary clarifier, which is 140 ft. square and 9 ft. deep from the flow line to the intersection of the

* Operator, Phoenix Sewage Treatment Plant.

vertical wall and hopper bottom, and is equipped with Dorr traction mechanism. The effluent from the secondary clarifier discharges into a chlorine contact channel, a gunited ditch 825 ft. long, 5 ft. wide at the bottom, and 8 ft. deep, which is connected by a short pipe to a ditch 1500 ft. long, through which the plant effluent flows to the main channel on the north side of Salt river.

A sludge thickener, 35 ft. diameter and 9 ft. deep from the flow line, furnished with special Dorr traction apparatus, was provided to increase the percentage of solids in the sludge pumped to the digesters. This reduces the quantity of sludge pumped, with consequent reduction of overflow liquor from these tanks. The overflow from the thickener is returned to the inlet weir of the preliminary clarifier.

The digestion units consist of two 60-ft. diameter Dorrco digesters, 23 ft. deep, equipped with heating coils. The gas collectors are connected with a gas holder of 950 cu. ft. capacity. Overflow liquor can be discharged either to the preliminary clarifier or to the thickener.

Six drying beds 125 by 40 ft., with tile underdrains, are equipped with a belt conveyor which can be moved from one bed to another. Dried sludge shoveled onto the conveyor is mechanically loaded into trucks.

Operation—The sewage flow was turned into the plant on March 15, 1932. The aerators and secondary clarifier were not yet completed, but it was thought advisable to use the primary units in order to start digestion. Also, the sewage would receive primary clarification, which would be a great improvement over the septic-tank effluent, as the old tanks were so overloaded that little sedimentation was obtained and the sewage became septic and fouled with partly-digested sludge.

Oil caused a great deal of trouble during the first ten days of operation. An ordinance had been passed prior to March 15 prohibiting oil in sewers, and it became necessary to make a sewer survey to enforce the ordinance. During this time about 2000 gal. of oil skimmings were collected and buried.

The screenings obtained to date average 24.27 cu. ft. per day and are disposed of by burying in pits on the plant ground. In order to eliminate complaints from odors, flies, and unsightly appearance, the screenings are covered with a light layer of earth and sprayed with a solution of Germite at the time of dumping into the pits.

During the onset of summer, hydrogen sulphide became noticeable in the raw sewage entering the diversion chamber, causing odors at this point and at the screen house. In order to aid in odor control, the diversion chamber was covered, and a dry-feed chlorinator was borrowed from the water department to apply chlorine above the screen house. This procedure materially aided in control of odors at these structures, but the equipment was never intended to be operated under the conditions in which it was used and the method was abandoned with regrets at the request of the water department.

Although it was intended to use the thickener for wasted activated sludge, or the combination of activated sludge and sludge from the primary clarifier, it was decided to try to operate with primary sludge only. On March 16 the thickener was placed in operation, while one digester was being filled with groundwater. Sludge pumped to the thickener was fairly thin, estimated to be 2.5%; with 24-hour thickening the percentage of solids was estimated at three to four times this original value. (Our laboratory equipment had not arrived, so it was impossible to get accurate data.) An odor nuisance was being created, however, and, as it was necessary to maintain odors at a minimum, this method of operation was abandoned.

It is regrettable that our laboratory was not in operation during the 7 days in which this method of operation was in use, so that we might present actual figures of the effect of the thickener on primary-sludge concentration. However, it is my opinion that it could be used to advantage in plants so situated that odors are not of major importance and where climatic conditions are more favorable. Using this structure, the sludge in the preliminary clarifiers need not be held for as long a period as usual to increase the solid content; consequently, a fresher effluent can be obtained.

Digestion—The south digester was placed in service March 17, after being filled with water, so that all gas produced could be collected and odors minimized. The pH of the water was 7.6; but by March 29 the pH had dropped to 6.0 and it was necessary to add a half-ton of lime in 100-lb. charges to raise the pH to 6.6. On April 8, the pH again dropped to 6.0. Adding lime in 100 to 150-lb. batches, the pH was brought to 6.9 in 4 days after using 4000 lb. of lime. The digester temperature during the entire period averaged 72° F. On April 25 the pH had dropped to 6.4 and 2 tons of lime was added again to bring it to 6.9 after 4 days. The nights during the latter part of the month were warmer, and on May 1 digestion became violent; scum began to overflow through the manholes on the digester and also clogged the gas lines, the water sprays being insufficient to keep these lines cleared.

The north digester was placed in service May 2, contents from the south digester being drawn into it in just sufficient quantity to prevent scum from overflowing through the manholes of the south tank. Violent foaming continued in this tank for five days. The pH during this period averaged 6.8 and the temperature 75° F. In an effort to aid odor control, on May 5 the boiler installed for heating the digesters was placed in service to burn the gas generated.

After 3 weeks' use the north digester began to foam, scum escaping through the manholes; and a day later the south digester again foamed. Both digesters became violent in another 2 days, and sludge was drawn on the drying beds in sufficient quantities to prevent scum overflowing. The thickener was placed in service at this time, with the object of storing sludge while the digesters were rested. Chloride of lime and plant effluent were used to prevent odors. During this time the digester pH had been maintained between 6.8 and 7.0 by add-

ing lime in 100-lb. charges whenever it dropped below 6.8. The temperature averaged 85° F. Sludge drawn on the beds contained 9.4% solids and 49% volatiles, while the primary sludge added to the digesters averaged 3.9% solids and 69% volatiles.

In a few days the digesters had quieted down, so the thickener was taken out of service, and the sludge collected in it was pumped to the digesters, where the pH was maintained continually above 6.8 by addition of lime. The temperature had been raised to 90° F. by the circulating hot water. With the high temperatures of summer at hand, a relief gas line was installed so the gas could be burned with flares and use of the boiler was discontinued. During this period it was noticed that when the gas production from each digester exceeded 12,000 cu. ft., the scum would overflow through the manholes, as if it were under a back pressure. In order to save the disagreeable work of cleaning the digesters after overflowing, the wooden manhole covers on top were calked and weighted. After this was done no trouble was experienced with scum escaping, although mild foaming occurred during the month of June.

Whenever foaming occurred, the gas lines would clog, the sprays apparently not being sufficient to prevent scum from entering the pipes. However, installation of a gas-line flushing system was well worth its cost in the saving of time required to disconnect the gas lines for hand flushing. Also, it eliminated loss of gas during these periods (an important consideration in Phoenix, as odors must be guarded against at all times).

Activated sludge was first wasted on June 2. At this time, daily gas production amounted to 23,000 cu. ft. per day or 0.37 cu. ft. per capita. The digesters had a temperature averaging 90° F. and the pH was 7.0. The gas production rose steadily with the addition of activated sludge, reaching a maximum of 85,770 cu. ft., or 1.43 cu. ft. per capita per day, on June 27. The pH was maintained from 6.8 to 7.0 with lime, the average daily quantity of lime used being 160 lb., or 20.3 lb. per m.g.

With the rapid gas production in June, trouble was experienced with overflow liquor containing great quantities of solids which fouled the thickener and preliminary clarifier. This condition became worse as the quantity of activated sludge wasted was increased in July and August. Sampling of the digesters in the early part of August indicated 8 in. of scum and no supernatant liquor, both digesters being full of light sludge, averaging 2.8% solids by dry weight. The sludge on the bottom of the digesters was of the same density as that at the overflow line. The alarming increase in moisture content of the sludge from 90% to 97.2% resulted in increased seeding ratios and a reduction of the detention period for digestion. This caused a decrease in volatile-matter reduction and increased the solid content of the supernatant liquor.

In order to relieve the septic condition of the preliminary clarifier and thickener, caused by the digester overflow liquor, a sufficient quantity of sludge was drawn on the drying beds to take care of the

pumping necessary to clear the primary clarifier and thickener of collected solids without obtaining overflow from the digesters. The sprays in the gas domes were shut off to help reduce the quantity of overflow liquor. Also, the wasting of activated sludge was reduced to lighten the load on the digesters by allowing the per cent of solids in the aerators and reaerators to increase, and by thickening the sludge to a greater density than had been obtained before, so as to reduce the quantity pumped. This procedure caused local odors at the thickener. An effort was also made, without success, to coagulate the sludge in the digesters with lime.

The procedure outlined, although apparently sound in theory, failed in practice. The sludge in the digesters remained in suspension, while the preliminary clarifier and thickener continued to be fouled by the digester overflow. This recirculation of sludge, which continued until August 24, resulted in deterioration of the preliminary-clarifier effluent. During this period, with its high atmospheric temperatures, septic sludge formed an unsightly scum on the preliminary clarifier faster than it could be handled by the skimming device.

At this time it was decided to install a line from the digesters to the sludge-drying beds to dispose of the overflow liquor. Since this line was placed in service, a marked improvement in plant operation has been obtained. This change of procedure has not created any odor nuisance, as the sludge beds are so located that odors are only discernible 150 yards away on city-owned property.

The gas production was reduced in quantity to an average of 0.36 cu. ft. per capita per day during the period that the trouble experienced with the digester overflow liquor was at its worst. Since the overflow has been diverted to the sludge-drying beds, and reduced in quantity to a minimum by the procedure previously outlined, and the settling rate in the digesters decreased by pumping simultaneously into both digesters, the gas production has been steadily increasing and is at present over 0.5 cu. ft. per capita per day. Samples from the digesters on September 9 showed that the sludge had increased in density to 4.1% solids, and the quantity of solids in the overflow liquor had materially decreased. The pH of the digesters averaged 7.3 and the temperature 86° F.

Aeration—On March 28, the two aerators then completed were placed in service on the fill-and-draw principle to start building activated sludge. A week later the last aerator had been completed; the plant continued to be operated in the above manner until the secondary clarifier was ready the middle of April. Some trouble was experienced during this period with the jumping of chains driving the paddles, and we were also bothered by the cutting out of overload relays. Only one blower was used, supplying air at the rate of 700 c.f.m. or 0.13 cu. ft. per gal. of sewage.

On April 13, the secondary clarifier was ready for use; three aerators were kept in service on a continuous-flow basis, the air being increased to 1000 c.f.m. or 0.19 cu. ft. of air per gal. of sewage. Sludge

built very slowly with this procedure, and the aerators emanated a foul odor due to lack of air. On April 23 two blowers, each delivering 850 c.f.m., were placed in service. This increased the air to 0.32 cu. ft. per gal. of sewage and caused a marked improvement in the condition of the aerators. The reaerator was not put in operation to treat the small quantity of sludge already produced, which amounted to 4% by volume with 1 hour settling.

On April 27, following the recommendation of A. M. Kivari of the Dorr Co., the angle of the paddles of one aerator was changed 30 deg. in the direction of rotation. This was done with wood wedges. Power tests indicated that a saving of 20% in power was obtained by this change. Later, E. M. Kelly of the Dorr Co. arrived to change the angle of the paddles in the remaining aerators and reaerator in order to reduce the power consumption. This work required 12 days, but power readings obtained after its completion indicated a saving in power of 20%.

On April 28 the city of Phoenix formally accepted the plant from the consulting engineer, and I was placed in charge of operation, the original agreement being that the consulting firm operate the plant for a month after completion.

Five aerators were placed in service on May 1, the air being maintained at 0.32 cu. ft. per gal. of sewage. Activated sludge increased in volume from 5% to 15% in the aerators, and to 50% in the reaerator, while the plant effluent showed better clarification.

In Phoenix it has been found that to prevent odors at the air lifts used to return the activated sludge to the reaerator, the d.o. in the secondary clarifier must be maintained above 0.4 p.p.m. When the d.o. drops below 0.2 p.p.m., the odors become objectionable. To satisfy this condition, it became necessary to use three blowers in July. In order to reduce the amount of power consumed, the retention period during the latter half of July was lowered to 6.3 hours by using three aerators instead of five, with good results. Following the rule of all plants, i. e., trying to reduce costs, we then tried to operate with two aerators, which would mean a saving of 20 h.p. The quality of the effluent deteriorated, however, so the third aerator was again placed in service and operation continued with three blowers in use from 9 a.m. to 8 p.m. and two blowers from 8 p.m. to 9 a.m. Very good results were obtained from this procedure.

The latter part of July, H. R. Dunn of the Dorr Co. arrived to change the chains and sprockets of the drive units on the aerators, as the original ones were too light.

The trouble with the digester overflow liquor returned to the thickener and primary clarifier has already been mentioned. During August, it became so bad that the clarifier effluent contained more suspended and settleable solids and had a higher b.o.d. than the raw sewage. The poisoning effect of this overflow caused deterioration of the activated sludge during the latter part of the month, resulting in an increase in turbidity, free ammonia, and b.o.d. of plant effluent, and a noticeable drop in the amount of d.o. in the secondary clarifier.

Since the digester overflow has been diverted to the sludge drying beds, we have been able to obtain excellent results with three aerators, the reaerator, and two blowers, each delivering 900 c.f.m. of air, which at present amounts to 0.31 cu. ft. per gal. of sewage.

Since the aeration units have been in service, mechanical repairs have made it necessary to operate at times without the reaerator. During these intervals the sludge bulked slightly, and the quality of the effluent deteriorated. From our short experience with the plant we feel that the reaerator is a necessary feature to this type of plant.

Sludge Thickener—The use of the thickener with primary sludge has been mentioned. Its use for settling combined primary and activated sludge has shown that we may expect a material reduction in the amount of sludge to be pumped to the digesters, due to increase in per cent of solids in the thickened sludge. That use has permitted removal of sludge from the preliminary clarifier at a higher dilution than would have been possible if it were pumped directly to the digesters. This reduces the detention period and eliminates the danger of septic action in the clarifier, which has been rapid on account of the hot weather in Phoenix. We have not yet demonstrated to our satisfaction to what density the sludge may be thickened. Due to high atmospheric and sewage temperatures, we have felt it necessary to remove sludge more often than is perhaps ordinarily done in order to prevent septic action, as it is imperative that we maintain odors at a minimum.

Conclusions—The Phoenix plant has been in service too short a period to have operating routine fully established. However, it appears that:

1. Use of mechanical agitation with small quantities of air, an average to date of 0.34 cu. ft. total air per gal. of sewage, or 0.29 cu. ft. net air per gal. of sewage has produced a well-clarified stable effluent in Phoenix.

2. Reduction of suspended solids has averaged 90.0% and b.o.d. reduction has averaged 93.7%.

3. Reaeration of the returned activated sludge seems to be necessary. During the short intervals when the reaerator was out of service on account of mechanical breakdowns and repairs, a deterioration of the sludge occurred, with consequent reduction in quality of plant effluent.

4. Addition of activated sludge to the digesters caused a marked increase in gas production from 23,000 cu. ft. per day on June 2 to 85,770 cu. ft. per day on June 27.

5. Addition of activated sludge to the digesters caused an alarming increase in the moisture content of the sludge, which resulted in increased seeding ratios and reduction of the detention period allowed for digestion. This condition resulted in excessive discharge of solids in the digester overflow, which fouled both the thickener and primary clarifier, necessitating removal of the overflow from these structures to prevent a reduction in quality of plant effluent.

6. The problem of reducing moisture content of sludge in the digesters presents opportunity for considerable study, and we will have to devise a proper procedure to handle this situation.

7. Use of the thickener for settling combined primary and activated sludge has effected a material increase in per cent solids in the thickened sludge, with consequent reduction in the quantity pumped to the digesters.

CHEMICAL DATA—MONTHLY AVERAGES

	June 1932	July 1932	August 1932	Sept. 1 to 15, 1932
Raw Sewage:				
Total solids, p.p.m.	2463	2440	1781	1464
Suspended solids, p.p.m.	257	258	154	135
Volatile solids, per cent	70.4	67	75	.....
Free ammonia, p.p.m.	10.1	2.8	2.9	6.0
Sulphides, p.p.m.	1.02	1.5	1.17	0.5
B.O.D., p.p.m.	.....	193	149	182
pH	7.2	7	7.4	7.6
Temperature, °F.	82	83.5	85.5	84
Preliminary Clarifier Effluent:				
Total solids, p.p.m.	1900	2045	1798	1277
Suspended solids, p.p.m.	137	220	210	55
Volatile solids, per cent	66	67	75	.....
Free ammonia, p.p.m.	8.0	3.6	4.5	5.4
Sulphides, p.p.m.	2.06	1.6	3.3	0.5
B.O.D., p.p.m.	.....	150	195	102
pH	7.2	7.3	7.3	7.6
Temperature, °F.	.....	84.2	85.6	84
Plant Effluent:				
Suspended solids, p.p.m.	11.3	23	27.0	21
B.O.D., p.p.m.	.....	18.6	9.0	5.7
Dissolved oxygen, p.p.m.	0.81	2.4	1.41	2.5
Free ammonia, p.p.m.	4.1	2.4	2.2	1.7
Nitrites, p.p.m.	0.0	0	0.2	0.1
Nitrates, p.p.m.	1.7	1.41	0.79	2.1
pH	7.3	7.3	7.5	.....
Temperature, °F.	82.5	85	86.0	84

OPERATING DATA—MONTHLY AVERAGES, 1932

	June	July	August	Sept. 1 to 15
Total sewage flow, m.g.	236.14	267.80	272.22	130.26
Average flow, m.g.d.	7.87	8.64	8.78	8.68
Power, kw.-hr. per day	4,500	4,281	3,457	3,380
Hp. per m.g.	31.8	27.60	21.98	21.76
Total air, cu. ft. per gal.	.....	0.41	0.316	0.31
Net air, cu. ft. per gal.	.....	0.375	0.275	0.26
Screenings, cu. ft. per day	24.99	22.68	23.20	25.10
Screenings, cu. ft. per m.g.	3.17	2.62	2.61	2.89
Primary sludge, gal. per day	.....	.....	26,814	35,410
Primary clarifier—detention—hours	.....	1.47	1.45	1.46
Aeration time, hours	.....	7.24	6.02	5.33
Reaeration time, hours	.....	12.82	11.97	8.26
Sludge return, per cent	.....	18.2	17.8	28.2
Excess activated sludge, 1000 gal. per day	.....	24,800	52,032	43.450
Detention, hours, secondary clarifier	.....	3.10	3.04	2.82
Atmospheric temp., av. max.	100.6	105.8	104	103
Atmospheric temp., av. min.	67	79.2	76	71
Total gas produced, cu. ft.	1,330,154	1,550,113	961,225	392,810
Gas produced, cu. ft. per day	44,338	50,004	31,007	26,190
Gas produced, cu. ft. per capita per day	0.74	0.83	0.517	0.436

OPERATING COST (LABOR, POWER, SUPPLIES)

	June	July	August
Cost per m.g.	$ 12.29	$ 10.44	$ 10.21
Cost per capita (60,000)	0.0483	0.0466	0.0463
Total operating cost per month	2,902.40	2,797.50	2,780.11

DISCUSSION OF D. TRAVAINI'S PAPER

By JANE H. RIDER*

Two and a half years ago the Arizona State Board of Health was requested to make a sanitary survey of the Salt river and the adjacent canal system. This was done with the cooperation of the U. S. Public Health Service and the city engineering department of Phoenix. The results indicated that the condition of the riverbed below Phoenix was so contaminated that steps should be taken by the city to treat sewage in such a manner that it would no longer grossly pollute the stream channel. As described by Travaini, unclarified effluent from a heavily overloaded septic tank flowed through the ditch for 3 mi. to a ranch, where, presumably, it was disposed of by the broad irrigation form of land treatment. Excellent in theory, except the fields under most favorable conditions could utilize only 294 m.g. of sewage a year, whereas the city delivered some 2500 m.g. to the ranch during this period. Even the high evaporation rate of an arid country could not take care of such an excess, which perforce found its way into the main north channel of the riverbed after creating many unsightly, malodorous ponds and puddles.

Any night those driving for pleasure or business along the Yuma highway, 2 mi. away, could detect the evil smells of the ditch. Naturally, this intolerable situation brought many complaints from the farmers residing in the district and suits were threatened unless the city took steps to lessen the nuisance.

A more serious aspect from the standpoint of public health was pollution of water diverted from the river by the U. S. Indian Service for irrigation purposes. Those who are familiar with irrigated districts will know that such water may be used for all household purposes, irrigation canals being the brooks of the desert. The Indian Service had filed a formal protest with the U. S. Attorney for the district, action being held in abeyance pending the institution of remedial measures by Phoenix.

It is needless to go into the details of the 1930 sanitary survey, as a brief resume of the findings will indicate conditions at that time. The ditch carried septic sewage—effluent is too dignified a term—for 3 mi. along the river bank to the disposal farm. Here it was applied to the land as needed and the excess flowed slowly away in a smaller ditch, frequently overflowing onto other land, creating many malodorous, mosquito-producing pools. The plan was to keep it out of the riverbed until it reached a point below lateral 17, where the diversion dam for the Indian Service canal was located. The accidental spilling of this noisome liquid above the dam always seemed to occur on days of inspection, making us feel the Indians had just cause for complaint.

The north channel of Salt river below the Indian dam was a veri-

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table bubbly creek, with its full quota of the unpleasant characteristics of undiluted sewage. This aggrevated condition persisted for 1½ mi. A mile further downstream the river began to clear up; low velocity allowed solids to settle; and seepage water furnished some dilution. At the end of 5 mi. there was only slight physical evidence of pollution. This furnished the greatest hazard to health, as it was occasionally used for swimming, the isolated locality furnishing the chief factor of safety.

This information is necessary in order to comment on changed conditions. The city, in making plans for sewage treatment, had to find a method that would minimize odors and render an effluent suitable for irrigation purposes. Travaini has given a brief description of the plant installed and details of the operation; you can judge from this the improvement in the character of the effluent. The first 2 weeks of this month were spent in re-surveying the district to estimate the sanitary condition at that time. The physical findings were checked with chemical and bacteriological examinations.

Formerly, sewage in the ditch 3 mi. below the old septic tanks had 190 p.p.m. b.o.d., with an average of 10,000 B.coli per c.c. Our recent findings show 1.3 p.p.m. d.o., a b.o.d. of 1 to 2 p.p.m., and an average of 100 B.coli per c.c. During the 1930 investigation, we believed the maximum pollution occurred 4½ mi. below the present plant. The river at this point showed unmistakable evidences of putrifaction, had a b.o.d. as high as 203 p.p.m., and 10,000 B.coli per c.c. Now there is 4.6 to 12 p.p.m. d.o. and 0 to 1 p.p.m. b.o.d. An average of ten results shows a total count on agar of 1570 bacteria per c.c.

The river bed above the farm is entirely dry at this time of the year. Along the farm land a small quantity of groundwater seeps to the surface in several channels, forming a small stream. Also, it is possible for leakage from the fields to get into the river. Below the farm where a road crosses the river, the water appears clear and unpolluted to the casual observer. The laboratory results showed an average total count of 2000 bacteria per c.c., and 105 B.coli per c.c. The d.o. varies from 6.4 to 10.0 p.p.m., with a b.o.d. of 1.0 p.p.m. The great improvement in the physical appearance of the river is creating a new danger. The country folk, not able to recognize the nature of plankton growths associated with pollution, bathe in it on hot days. Pending further treatment of the effluent to check the growth of pathogenic organisms, the city has placed signs in Spanish and English at the river crossings to warn the public that the water is unsafe for bathing.

We feel the odors have been reduced and that they should be further minimized when a routine operating procedure has been established. At times odors are discernible in narrow bands as far as a half-mile from the plant, hydrogen sulphide predominating when operating conditions are unfavorable. On other evenings we could detect the odor of influent from the screen house. It is too early to judge the full capacity of plant performance, but certainly conditions along the Salt river below Phoenix have been materially improved.

POSSIBLE POLLUTION OF WATER THROUGH USE OF TOILET FLUSH VALVES

By WALTER PUTNAM*

About 3 years ago we first began to hear rumors that under certain conditions there might be pollution of the domestic water supply through toilet flush valves. We were then engaged in a campaign to reduce cross-connections through hospital fixtures, swimming pools, and various similar installations. It had been a very startling revelation to find that a large part of the latest hospital equipment might, under circumstances easily possible, cause direct pollution of the water supply. We therefore started at once to investigate the new rumors, and the more we investigated the more we found investigation necessary.

Our first experiment was to run a pipe to the roof of a 1-story building, attach a popular make of flush valve to the top of it, fill the pipe and valve with water and, after submerging the end of the discharge pipe in a bucket of water, open the drain valve at the bottom of the pipe. To our great surprise the bucket was drained in a few seconds. This experiment was repeated a number of times and always with the same result.

The Pasadena Water Department then became interested and supplied us with the pipe and fittings to set up at a location where we had a drop of 35 ft. Our pipe was 1-in. and with this setup we proved that with a fairly high vacuum most of the valves would siphon. We next set up a 2-in. pipe 60 ft. high, which was equipped with a water supply valve and a 2-in. quick-opening valve at the bottom, and a vacuum gauge and valve at the top. By filling the vertical pipe with water and then draining, we could regularly produce a vacuum of 27 in. With this setup it was possible to siphon a number of flush valves which had withstood all previous attempts.

We worked with this setup for about a year and learned many interesting things, but the flush-valve people came back at us with the statement that this was not a fair test. They claimed that the vacuum was higher than could ever be produced in practice and that the air entering through the rim openings of the toilet bowl would break any vacuum before siphonage could take place. Even if it could be proved that a vacuum would never occur when a bowl was flooded, we think it very unsafe to draw large quantities of air into the water pipes through the rim openings of a toilet bowl. These openings are subject to serious fouling, and air entering through them at high velocity might and probably would carry fecal and other polluting matter into the water system.

It thus became clearly evident that we would need to have a setup

* Superintendent of Building Inspection, City of Pasadena.

where we could maintain any given vacuum for considerable periods of time, even while air was freely entering through the rim openings of the bowl. At our sewage treatment plant there are large vacuum pumps in continuous operation and, with the cooperation of the city engineer and the superintendent at the plant, we set up what proved to be a very satisfactory test. We borrowed three modern toilet bowls, one top inlet siphon-jet, one side inlet, and one washdown bowl with a jet. Our setup was such that we could use any of these bowls, and could subject the flush valve under test to water pressure under normal conditions, or to varying degrees of vacuum.

The procedure was to connect the flush valve to the toilet bowl in the usual manner, turn on the water and operate the valve a number of times to be sure that it was operating normally. Finally, we let it close under water pressure as it would in normal service. The water was then shut off and the vacuum valve opened, thus simulating conditions resulting from a vacuum in the water supply pipes.

Our first work was done with valves which we knew would open under a vacuum, and the first surprise was the small amount necessary to open the valve—1 or 2 in. of vacuum being sufficient. We had thought that we might be able to siphon a bowl, even with the rim openings clear, but that it would probably take a high vacuum to do it. Actual tests show that a vacuum of 2 to 3 in. will siphon the contents out of any bowl which is provided with a jet opening below the water level, provided it is equipped with a flush valve which will open when a partial vacuum occurs in the water line. This is not an occasional result, but will always take place under these conditions.

There are a number of flush valves which will not open under a vacuum, but which will let water through the bypass if the toilet bowl is flooded so that the water therein stands above the level of the rim openings. This may seem like a very unlikely combination of circumstances, but such information as we have been able to gather indicates that it might very easily occur. Our water department, under the direction of S. B. Morris, has attached a recording gage to a number of water mains when water was shut off and the main drained. The gage record shows that fairly high vacuum occurs, which may endure for a long period of time. The vacuum may reach 88% of that theoretically obtainable between the high and low points on the line. Even the opening of a fire hydrant at the upper end of the line will not prevent production of a high vacuum in buildings supplied from the main being drained.

A recording gage in one of our large public buildings showed momentary vacuum of several inches on the third floor every time a toilet was flushed on the lower floor with full water pressure on the line. In a neighboring city we had a case where flushing of the toilet on the first floor would always siphon all the contents out of the second-floor toilet. This was partly due to low water pressure and partly to inadequate pipe sizes.

These things, taken in connection with the known fact that there is hardly a day when we do not have a number of flooded toilet bowls due to stoppages in the house plumbing or house lateral, show that simultaneous occurrence of a flooded bowl and a vacuum on the water line is not such a remote possibility.

We next come to the problem of preventing siphonage, which is not so simple as might at first appear, but is nevertheless entirely possible. Our first idea was to provide some device which would admit air to the valve and so prevent siphonage, but tests have shown that it is not possible to admit enough air for this purpose. To show this we inserted the 1½-in. tail piece of a valve in the 2-in. spud of the toilet bowl, leaving the annular space of about ¼ in. open, and found that a 12 or 15-in. vacuum would still siphon the water out of the bowl. In this case the free-air opening was 82% of the area of the tail piece of the valve, and 30% larger than the 1-in. water pipe. Accepting this as proof that we cannot admit enough air to prevent siphonage, the most logical procedure is to design a valve which will not open under a vacuum, and this has been done in a number of ways. This, however, does not give full safety, as the bypass will still draw water from a flooded bowl.

A good many people have thought that complete safety could be procured by inserting a check valve between the flush valve and the water supply. We do not think that this provides the proper margin of safety. In the first place, check valves are not entirely dependable, even where they are carefully maintained. In such an installation a check valve would get no maintenance, for it is unnecessary to operation of the flush valve and there is nothing to indicate when it becomes defective. We believe that the safety device, whatever its nature, should be essential to the normal use of th flush valve, and that its failure to provide safety should put the flush valve out of business until repairs are made. This is about the only limitation we would put upon the safety devices.

There is one other feature which we consider essential to a flush valve, and that is a free and unobstructed air inlet of such size that it will admit enough air to prevent siphonage through the bypass and a leaking main valve seat. Our tests have shown that a flush valve attached to a bowl containing a jet may be leaking at the rate of 3 quarts per minute without showing in the bowl.

Some have thought that placing the flush valve several feet above the bowl would prevent siphonage. This might work with a low vacuum if the water rose in the pipe as a solid column, but it does not. In our tests we have used a transparent tail piece, connecting the flush valve to the toilet bowl, and have found that the water rises in the form of spray or as a thin film on the walls of the pipe, and in both cases is carried along by the rush of air entering through the rim openings. Thus we see that what was supposed to absolutely

prevent siphonage is one of the most potent factors in producing it.

If you will examine any modern toilet bowl you will see that the water surface is only about 3 in. below the rim openings. A quarter of an inch of vacuum will raise water 3.4 in. It then becomes evident that a vacuum of about ¼ in. in the water passages of the bowl will raise the water through the jet to the rim, and the air entering through the rim carries the water along wish it in the form of spray. We thus see that the location of the flush valve can have very little effect upon siphonage.

It is evident that if no water can be drawn out of the space above the operating piston or diaphragm of a valve, the valve cannot rise and no siphonage can then take place. Several manufacturers have introduced a ball check in the bypass and a reversed cup washer on the piston, and as long as these function perfectly no siphonage can occur except through a leaky main valve seat. Some manufacturers have also introduced an air inlet into the discharge passages of the valve. At first sight this would seem to make a perfectly safe flush valve; however, there are several objections to it.

The slightest leakage in either the ball check or the reversed cup washer will allow water to be drawn from the piece above the piston or diaphragm, thus allowing the main valve to open and produce siphonage. Furthermore, there is no way of knowing when these parts become defective, as they have no function in the normal action of the valve. The air inlet also presents some problems. If it leaks water on the floor the owner will plug the hole. One such valve has proved to be very noisy as air is drawn in at the end of each flush, and this can be heard through several rooms. This is also likely to cause the owner to plug the hole.

So far as we know, there are only two ways in which 100% safety can be obtained. One is to use a separate pipe system to supply all flush valves, and connect no other fixtures to this system. Then this pipe system should be supplied from a tank with an over-the-rim supply. The other is to use no flush valves. But I do think it is perfectly feasible to use properly-designed flush valves and obtain probably 98% or 99% of absolute safety.

While this paper has been devoted to flush valves, they are by no means the only sources of water pollution. We are continually finding new devices offered for sale which product direct cross-connection between the water supply and various chemicals and other substances. These all need careful watching. Finding and eliminating possible sources of pollution has become one of our favorite indoor sports.

The following table, compiled by our Water Department, shows vacuum measurements on several water mains. These were recorded when the mains were shut off for repairs:

PASADENA WATER DEPARTMENT

RESULTS OF TYPICAL TESTS FOR PARTIAL VACUUM OCCURRING IN DISTRIBUTION SYSTEM WHEN WATER MAINS WERE SHUT OFF AND DRAINED

Test No.	1	2	3	4
Date	1/9/32	3/21/32	3/29/32	4/1/32
Size of main, in.	4	16	4	6
Length of main, ft.	540	410	1175	863
Diff. in elev. of gage and outlet, ft.	10.5	12	18	20
Diff. in elev., in. of mercury	9.3	10.6	15.9	17.7
Vacuum in in., following shut off in 0 min.	7	0	0	0
2.5 min.	5	2	2	3
5 min.	3	3	2	12
7.5 min.	2	4	2	8
10 min.	1	5	14	2
12.5 min.	.....	5	10	0
15 min.	.....	6	4	.....
17.5 min.	.....	6	3	.....
20 min.	.....	6	2	.....
25 min.	.....	6	2	.....
50 min.	.....	6	.....	.....
60 min.	.....	5	.....	.....
Maximum vacuum, in.	7	6	14	12
Vacuum in % of diff. in elev. gage to outlet	75	57	88	68

Note: In test no. 4 the partial vacuum was 2 in. at 2 min., falling to 0 at 3 1/3 min. when open garden valve was closed and increasing again to 3 in. at 2½ min. At 7 min., with vacuum at 11 in., the garden valve was again opened to completion of the test.

FIELD EXPERIMENTS IN PROBLEMS OF WATER CONTAMINATION FROM PRIVATE FLUSH VALVES

By JEAN VINCENZ*

The city of Fresno does not have the mechanical set-up which Pasadena has for testing flush valves as regards siphon action. However, we have made some experiments that were considered very much worth while, as they took conditions as they actually were and show results that actually do occur.

The most important test made by the plumbing inspection bureau of the Fresno Public Works Department was at Winchell school in Fresno. The test was made in the presence of the head janitor of the school and under the direction of F. R. Twining, head of the Twining Laboratories, testing engineers.

The following is a general description of the layout considered:

The toilet rooms of the boys and girls are located along a north wall, with a separation of about 80 ft. between the two rooms.

* Commissioner of Public Works, City of Fresno.

Eighteen toilets are located in the girls' room, and 12 toilets in the boys' room. The water supply to these rooms is furnished through a 3-in. main line supplying the school buildings. This main line extends through the building, and in the basement is carried about 2 ft. below the ceiling.

At the south end of the basement a sand trap, or sand tank, has been placed in the 3-in. main line to receive sand that might be pumped into the city mains. A 2-in. valve is located at the bottom of the sand tank for drawing out the accumulation of sand into a sump. From the 3-in. main line, branches of 2½ and 2-in. pipes carry the water to the battery of toilet bowls, reducing to as small as a 1-in. pipe. All other plumbing fixtures in the building are supplied by the same 3-in. main.

In carrying out the test, no alterations were made in any part of the plumbing or water system. Three toilet bowls in each toilet room were selected and the water supply to the others was shut off. The six toilets were then cleansed and disinfected. Twining then placed in each of the bowls a solution of fluorescin. The main supply valve, which is located in the basement, was next shut off. The drain valve on the sand tank was then opened and the water allowed to flow into the sump until the 3-in. supply line was almost drained.

This action is about what would occur if the water supply were shut off in a school or office building to repair a valve in the basement or on the first floor.

Inspection was then made of the toilet bowls and it was found that from one bowl out of the three in each set, the water had been entirely siphoned, while water sealed in the other four bowls had been largely siphoned out. The main supply valve was again turned on and samples of water were taken from the drinking fountain and from the sand tank. It was even apparent to the eye that the fluorescin which had been placed in the toilet bowls, was present in the water drawn from the drinking fountain and sand tank. This proved that the solution from the toilet bowls had been drawn into the main water supply of the entire building.

The final paragraph of the report presented by the Twining Laboratories reads as follows: "This shows that under conditions which may occur quite often, materials from toilets may be siphoned into the water supply."

In this particular test it is evident that no suction was applied to the lines but merely siphon action took place, with the results noted. Some plumbing inspectors have realized that these results might occur in the case of a main breaking. But, it may be seen from the test that such simple matters as the changing of a washer in a faucet, drinking fountain, or other appliance where the valve at the main supply has been cut off, may result in this action.

Another test of a different character was made at the Columbia school. The supposition was in this case that there might be a fire

either in the school or in the immediate neighborhood. A regular fire-department pumper was attached to the fire hydrant nearest the school grounds. This fire hydrant connects with the 4-in. main that runs through the school grounds and from this main the entire water supply for the school is drawn.

Several of the bowls in the boys' toilet were cleaned and a solution of fluorescin put in the bowls. All other bowls were shut off. With no other alterations the fire department pumper started to work, and practically instantaneously the bowls were siphoned. The pumper was allowed to run for several minutes and then shut off. Samples of the water were then taken from the draining fountains in the school yard and, in all cases, fluorescin was present, according to the report of the chemist.

Some of you may consider that this is all very interesting from an experimental standpoint but that the practical danger is very small. You may, therefore, be interested to know that on each of the visits I have made to this school, six or eight of the bowls were found to be unflushed. This is, undoubtedly, because the school is located in one of the poorer territories of the city, but, nevertheless, is something to think about.

At one of our new high schools, another very practical experiment was conducted. It was assumed that one of the garden valves in the lawn needed repairing. The valve in the main line which feeds the entire lawn-sprinkling system, and buildings as well, was shut off at the curb. One of the garden valves was then opened, as would be the case in making a repair. It was found, upon investigation, that practically any of the bowls could be siphoned if enough water were allowed to run out.

It so happens that practically all of the bowls in our public-school system are of the same general type, so that the same experiments could be applied to any of the schools. Naturally, the results would be the same in any of the buildings or apartment houses using this type of flushometer and the ordinary bowl.

However, there is one type of bowl which under ordinary conditions we have been unable to siphon, even though the flush valves were exactly the same as in the schools where the experiments were made. This experiment was made at the Fresno State College. The bowls used at the college are of the Crane type, the water supply into the bowl being higher than ordinary (at the same elevation as the lower part of the rim). When our experiment was attempted on this setup, air was immediately sucked in through the rim of the bowl and no siphon action was allowed to take place.

It is encouraging to know that there are groups studying these problems. It is also encouraging to know that manufacturers of plumbing supplies are recognizing these problems and are trying to improve their supplies.

1933 SPRING CONFERENCE

San Luis Obispo

May 5-6, 1933

Headquarters, Anderson Hotel

Program

FRIDAY, MAY 5

8:00 a. m. —Meet at Hotel Anderson.

8:30- 9:30 a. m.—Inspection of San Luis Obispo separate sludge digestion plant and sewer farm.

9:30-10:00 a. m.—Inspection of Arroyo Grande Imhoff tank and sand beds.

11:00-11:45 a. m.—Inspection of Pismo Beach settling tank and ocean outfall.

12:00-1:30 p. m. —Clam luncheon at Pismo Beach. Return to San Luis Obispo.

2:00- 5:00 p. m.—Symposium on 'Chemical Precipitation of Sewage'.
(a) 'History', by Leon B. Reynolds.
(b) 'Palo Alto Experiences', by Ralph A. Stevenson.
(c) 'What Others Are Doing', by Charles Gilman Hyde.
'Incineration of Screenings, Skimmings, and Sludge', by J. J. Jessup, A. P. Banta, and R. F. Goudey.
Symposium on 'Hazards':
(a) 'Cross-Connections Between Water and Sewage Systems', by Carl Wilson, R. L. Derby, and C. W. Sopp.
(a) 'Detection and Measurement of Gases', by S. H. Ash.
(c) 'Hazards, Gas Masks, and First Aid', by Carl Fry, F. D. Bowlus, and Fred West.

6:30 p. m. —Dinner and round-table discussions.

SATURDAY, MAY 6

7:30 a. m. —Breakfast and round-table discussions.

9:00-12:00 —General Symposium on 'Sewage Works'.
(a) 'Changes in Character of Sewage', by W. A. Allen, F. S. Currie, and W. C. Roberts.
(b) 'Keeping Power Bills Down', by Thomas, H. K. Palmer, and A. W. Wyman.
(c) 'Tax Delinquencies in Sanitary Districts', by C. R. Compton, D. E. Perry, and G. C. Zuckweiler.
(d) 'Design of Gas Lines and Holders', by T. R. Haseltine. Discussion by C. C. Kennedy, H. B. Hommon, and M. L. Crist.
(e) 'Law on Liability for Sewage Disposal', by Hugh Gordon. Discussed by B. J. Pardee.

12:30 p. m. —Informal luncheon and adjournment.

FIFTH ANNUAL C.S.W.A. SPRING CONFERENCE AT SAN LUIS OBISPO, MAY 5-6, 1933

By E. A. REINKE*

Morning Session, May 5, 1933

A group of 60 C.S.W.A. members and guests assembled at the Anderson Hotel, San Luis Obispo, and proceeded by automobile caravan to the San Luis Obispo (pop. 9090) sewage treatment plant. This plant consists of a Hardinge clarifier and a separate sludge digester designed for future installation of mixing, gas-collection, and heating facilities. Sewage effluent is used for irrigation on alfalfa and natural grass and sludge is dried on open sand beds. Some well-digested sludge was drawn for observation. The plant has the appearance of a well-kept farm.

The caravan then proceeded to the Arroyo Grande (pop. 856) sewage treatment plant, consisting of an Imhoff tank with discharge to natural sand beds. A novel feature of this plant is the discharge of effluent throughg a header pipe with ten outlets which are used in rotation, one each day, giving 9 days' rest between uses. The beds are simply channels which have to be cleaned at intervals of about 60 days. The plant is at ground level and sludge beds are in excavation. Natural sand is used for drying beds.

The caravan continued to the Pismo Beach Sanitary District (pop. 1500) plant, consisting of a settling tank with 12-in. gravity outfall to the ocean 1375 ft. beyond high tide. The State Department of Public Health arranged for the addition of uranin dye to the sewer. Operator Mahoney added the dye at 10:20 a.m., pumping sewage through the sludge pump to increase the rate of discharge. The dye appeared in the ocean at 11 a.m., just as the visitors arrived at the plant. It spread rapidly and with an on-shore wind was carried southerly parallel with the shore, finally diluted, and was lost to sight without coming ashore.

After a short trip to Pismo Beach heights for a splendid panoramic view of the Pacific ocean, the party met at Plessa's tavern, where a clam dinner was served to 85 members and guests. Through the courtesy of the city of San Luis Obispo, the cost to members was only 50c, or half the usual price. Members of the San Luis Obispo City Council and Pismo Beach Sanitary District Board present at the luncheon were introduced.

The party then returned to San Luis Obispo.

Afternoon Session, May 5, 1933

The meeting was called to order by president Jacobson. A symposium on 'Chemical Precipitation' was started by professor Leon B. Reynolds, with an excellent historical review of work done by investigators abroad as well as in America. Ralph A. Stevenson, of the Great Western Electro-Chemical Co., presented a summary review of his work at Palo Alto under the title 'Simplified Sewage Treatment with Ferric Chloride Developed at Palo Alto'. He concluded with the statement that "the sanitary profession has a new tool in the form of a simple chemical process, intermediate in effect, and intermediate in cost". Professor Charles Gilman Hyde gave a paper on 'Recent Developments in the Chemical Treatment of Sewage in the United States Outside of California' in which he briefly reviewed 18 processes to show the extent of the work recently done or now under way. He mentioned particularly the Streander process at Philadelphia, Cabrera-Maier process at Wilmnigton, and the use of ferric chloride at Oklahoma City.

* Secretary-Treasurer, California Sewage Works Association, Berkeley; Senior Sanitary Engineer, Bureau of Sanitary Engineering, State Department of Public Health.

In the Streander process lime, ferrous sulphate, and returned sludge are added to sewage and aerated through suspended air diffusors for a period of 20 minutes, using 0.08 cu. ft. per gallon. The mixture is settled 45 minutes and then filtered through a mechanically-cleaned sand filter. For the sewage treated 400 lb. of lime and 200 lb. of ferrous sulphate were found necessary, the cost being less than $5 per m.g. for chemicals and air. The b.o.d. reduction was 75%, stability 4 to 5 days, and effluent contained 4 to 6 p.p.m. d.o. It is proposed to dewater sludge on vacuum filters and incinerate it, with possible recovery of ferric oxide and lime.

The Cabrera-Maier process consists of treatment with aluminum sulphate (3 gr. per gallon) and returned chemical sludge (15% by volume) in a mixing tank, settling (30 minutes to 2 hours), and chlorination either before or after chemical treatment and settling. Reported results give a removal of 78% of b.o.d. and 89% of suspended solids. Excess sludge is digested and is said to be not materially different from plain settled sludge.

At Oklahoma City, L. H. Scott and R. J. Darcey have studied a process utilizing ferric chloride manufactured at the plant by use of scrap-iron turnings, water, and chlorine gas. A dose of 50 lb. per m.g. is said to effect a reduction of 95% in settleable solids and 85% in b.o.d. Destruction of bacteria is said to be complete and the effluent has an odor of very weak chlorine. The sludge does not dry readily; centrifuging gave good results and vacuum filtration will be tried.

Three papers in a symposium on 'Incineration of Screenings, Skimmings and Sludge', were next on the program. J. J. Jessup, city engineer of Los Angeles, presented a theoretical discussion of the various factors to be considered in a study of incineration, based largely on experiences with garbage incineration. He stated that in a year some actual operating data from Los Angeles may be available. A. P. Banta, assistant engineer, Los Angeles County Sanitation Districts, described an experimental incinerator, which handles skimmings after they are drained to about 50% moisture on sand beds. Combustion takes place at about 1700° F. without smoke of odor nuisance. The plant is manually operated. A rancid grease odor in the vicinity of the incinerator due to droppings during the charging, has been minimized by care in operation. R. F. Goudey, sanitary engineer, Los Angeles Water Department, presented a discussion of the subject of incineration, emphasizing the different characteristics of sewage sludges such as fresh, digested, fresh plus activated-undigested, and fresh plus activated-digested. Methods of dewatering were briefly discussed. The subject of sludge incineration appears to warrant further consideration.

Under the general title 'Hazards', two papers on cross-connections between water and sewer systems were presented. Ray L. Derby, of the Los Angeles Water Department, mentioned several kinds of connections, among them priming connections for sewage pumps, water connections to the sludge compartment of Imhoff tanks, drains from floors or pits in which sewage may back up to overflow wells or collection reservoirs, various plumbing fixtures of the home, hotel, hospital, and office building. C. W. Sopp, of the Pasadena Water Department, discussed operating conditions in a water system which would give partial vacuums. Among these are small pipes with low pressures and heavy drafts on lower floors; plumbers shutting off a service and draining lines; large drafts by fire engines on small or low-pressure mains; shutting off and draining mains for connections and repairs. A table showing partial vacuums actually measured in varying sizes of mains was presented, showing maximum values up to 14 in. of mercury.

A paper on 'Detection and Measurement of Gases', by S. H. Ash, district engineer, U. S. Bureau of Mines, was summarized by the author. He briefly stated the scope of activities of his bureau and discussed the various gases encountered in common practice, among them hydrogen, carbon monoxide, illuminants methane and ethane. Other gases mentioned are nitrogen, hydrogen sulphide, oxides of nitrogen, and sulphur dioxide. The author emphasized the necessity of definitely ascertaining the physiological nature of gases that may be encountered in an atmosphere of which it is desired to ascertain the constituents, stating that without proper protective equipment these atmospheres may prove fatal. He stressed the need of a trained observer to use flame safety lamps, and that all tests should be made by carefully-trained competent men and by no one else.

C. H. Fry, superintendent of safety, State Industrial Accident Commission, presented a paper entitled 'Hazards, Gas Masks, and First Aid'. Fry stated that the atmosphere in a sewer should be considered hazardous until proved otherwise, and cited several typical cases of asphyxiation and of explosion and fires in sewers. He drew attention to the limitations in use of gas masks, flame safety lamps, and mechanical forms of resuscitation. The latter, he stated, have not been approved by any recognized authority. He suggested that the committee of Safety Regulations from the Association meet with representatives of the U. S. Bureau of Mines, Industrial Accident Commission, and public utility companies having underground services to study the problems involved and promulgate explicit orders. (This will be done.)

Discussion was postponed until Saturday morning.

Dinner Meeting, May 5, 1933

Seventy-five members and guests assembled in the main dining room of the Anderson hotel for dinner. A number of round-table discussions were held and summarized by a leader from each table. President Jacobson called on professor Hyde to introduce the mayor and county health officer. Mayor L. F. Sinsheimer gave a delightful address of welcome in which he stressed the importance to municipalities and the public of our association's work. He spoke briefly of the historical background of San Luis Obispo and the mission which the ladies had visited in the afternoon. Finally he referred to the many attractions of the town, with an invitation to our members to return again and again. County health officer A. F. Gillihan spoke as a county official and as a member of the local arrangements committee. He told of the work of his office and invited our members to visit him there.

President Jacobson then called on leaders of the respective tables. T. R. Haseltine, Chester A. Smith, and F. V. Hammerly discussed the activated-sludge patents, with the general conclusion that cities should stand pat until further court decisions are obtained. Fred Bowlus and J. A. Harmon discussed the earthquake in southern California, with particular reference to breaks in water and sewer lines in Long Beach. Robert Linton and C. C. Kennedy reported on methods of obtaining R. F. C. funds. Linton also mentioned early work in development of clay tiles, and its relation to clay pipe, which had been done at the San Luis Obispo Mission. Kennedy gave the status of A. B. 980, the sewer-rental or sewer-revenue bond bill, which was passed by the Assembly and favorably reported out of committee in the Senate. Little opposition was expected.* This bill carries an emergency clause and satisfies the R. F. C. requirement for self-liquidating projects.

A feature of the dinner was the presentation of the award of merit donated each year by Wallace & Tiernan Co. Professor Hyde, reporting for the committee, said the plants applying for the award this year were all meritorious, and after careful consideration of all points the committee had concluded to give the award to the city of Salinas, with honorable mention to the city of Escondido, St. Mary's College and Yosemite Valley. He asked professor Leon B. Reynolds, of Stanford University, to make the presentation to his former student, T. R. Haseltine, operator of the Salinas plant. Reynolds complimented Haseltine for his hard work in face of many operating difficulties. In acknowledging the award Haseltine paid tribute to the city officials of Salinas who, he said, had supported him at all times and encouraged him to get the best possible results from the plant.

Morning Session, May 6, 1933

The meeting was called to order by president Jacobson.

Fred Bowlus, chairman of the Committee on Safety Regulations, reported progress of his committee, and proposed to meet with interested parties to draw up necessary rules. Alva J. Smith, chairman of the Committee on Licensing of

* Passed and signed by governor.—Editor.

Operators, also reported progress and suggested a joint committee with the American Water Works Association. J. C. Albers, chairman of the Legislative Committee for Southern California, reported that his group had held a number of meetings and corresponded with C. C. Kennedy, chairman of the northern group, with the result that the sewer-revenue bill was now well on its way toward passage. All committees were thanked by president Jacobson and instructed to prepare final reports for the annual meeting in Santa Cruz.

Continuing the progress, Fred D. Bowlus, resident engineer, Los Angeles County Sanitation Districts, presented a discussion of 'Hazards, Gas Masks, and First Aid', pointing out the intangible danger which workmen in sewers face daily, and the responsibility of the engineer or superintendent for their safety. He briefly mentioned the various gases most commonly encountered in sewers, some of the gas masks used, and testing outfits available. He strongly recommended the Schaefer prone pressure method of resuscitation for sewer-gas victims.

W. T. Knowlton, of Los Angeles, also discussed this subject, reporting that in 3450 manholes examined before and after the earthquake of March 10, 1933, only 1.2% had dangerous quantities before the earthquake, compared with 3.2% afterwards. He concluded that this increase was due to breakage of gas mains, etc.

Interesting papers on 'Changes of Character of Sewage' were prepared by F. S. Currie (read by the secretary) and W. C. Roberts (read by C. C. Kennedy). Discussion by A. M. Rawn, C. C. Kennedy, and A. A. Taylor brought out the following points: sewage flow had decreased slightly since the economic crisis; but little noticeable change was observed in strength of sewage; some increase in sewage flow, presumably from infiltration, occurred in several sewers immediately after the earthquake of March 10, 1933. At Signal Hill the sewage flow dropped markedly following the earthquake and gradually picked up as people moved back into their houses.

A paper entitled 'Keeping Power Bills Down', by Earl E. Thomas, General Electric Co., Los Angeles, was abstracted by C. G. Gillespie. Another paper on the same subject was presented by H. K. Palmer. These papers were discussed by Carl Hoskinson and C. C. Kennedy.

Papers on 'Tax Delinquencies in Sanitary Districts', by C. R. Compton (read by F. D. Bowlus), D. E. Perry, and G. C. Zuckweiler (read by the secretary), were next presented, outlining the difficulties in administration and methods used to handle the problems.

The final paper on the program, 'The Design of Gas-Collection Systems for Sewage Works', was by T. R. Haseltine, of Salinas. C. C. Kennedy, who was scheduled to discuss the paper, asked that his time be allotted to Haseltine so that this paper could be read in full, as in his opinion it was the most complete statement of the problem he had seen. The paper includes an extensive bibliography. C. R. Willette, of Yosemite, speaking for H. B. Hommon, presented the latter's regrets for not being in attendance. He also briefly commented on the paper.

The meeting adjourned at 12:10 p.m.

SEWAGE SCREENINGS DISPOSAL

By J. J. JESSUP*

Along with the developments realized in disposal of garbage and rubbish by incineration there has come a demand that a more inoffensive, sanitary, and scientific practice be adopted for disposal of sewage screenings.

The principles of refuse incineration have been the subject of much study and practice, extending over a period of 75 years in England and Europe and 50 years in America. Likewise, a great deal has been learned from the practice in many places of realizing the heat values in low-grade fuels by burning them in properly and specially designed furnaces. This paper will discuss the application of knowledge gained from such extensive experience to the matter of sewage screenings incineration.

While the first modern type of incinerator was constructed 75 years ago in England, and during the ensuing period much progress has been made, there is at present no standard practice as to any of the several features of incinerator design or operation. Methods of water treatment and sewage purification have been developed to a high degree of uniformity, and processes involved have been quite well standardized, yet no such statement can be made concerning garbage disposal by incineration.

Practically every city in America has had unfortunate experience in handling its garbage disposal problems. With many communities refuse incineration has taken its toll in sad experience and large expenditure for plants that proved to be short-lived, expensive in first cost, operation, and maintenance, and which—if not an actual nuisance —contributed little to the solution of the disposal problem.

It would therefore behoove engineers, about to set out upon sewage screenings disposal by a method that has been the source of more controversy than any other single municipal activity, to be sure that the history written in such sorrow as to garbage disposal be not repeated in application of incineration to screenings disposal.

Through the years, however, there have been established scientific principles and standardized practice that may be used or adopted by the engineer familiar with the subject in handling any situation that may arise. Arriving at the proper solution is an engineering matter, and should be so regarded if pitfalls are to be avoided.

Garbage and rubbish in the usual combined collection constitute a very heterogenous collection of material, varying widely in character, tractability, moisture content, and fuel value. Sewage screenings, however, may possess a good degree of uniformity as to character, consistency, water content, and fuel value.

The important consideration affording the fundamental basis for all design and estimates is that the material to be handled is a low-

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grade fuel with high moisture content. The discussion then resolves itself into the use of fuel of such low thermal value.

There has been a great deal of careful work done on this problem, with a view of steam production by use of low-grade fuel. In the Sandwich Islands and Cuba there is a scarcity of coal, and in the sugar industry steam in large quantities is necessary, as resort has been made to burning bagasse from sugar cane. Bagasse is the pressed canestalk and pulp left after extraction of juice. Its fuel value is about the same as that of pine wood in the corresponding state of dryness. As it comes from the mill it contains 50 to 80% moisture, the same as the average garbage and rubbish combined collection. In this state it is burned under water-tube boilers in specially designed furnaces, with very satisfactory results. However, careful attention is paid to maintaining proper burning conditions. Sawdust and spent tan bark are also used, and may be employed without auxiliary fuel in a properly designed furnace.

The following table gives some comparisons as to calorific value:

Fuel	B.T.U. Content	Fuel	B.T.U. Content
Natural gas	1,100 per cu. ft.	Bagasse, dry	8,000 per lb.
Coal gas	650 per lb.	Bagasse, 40% H_2O	5,000 per lb.
Fuel oil	17,000 per lb.	Bagasse, 50% H_2O	4,000 per lb.
Coal	15,000 per lb.	Bagasse, 60% H_2O	3,300 per lb.
Wood	8,000 per lb.	Average refuse	4,300 per lb.
Spent tan bark	6,000 per lb.	Sewage screenings	6,000 per lb.
Straws	5,000 per lb.		

It thus appears that sewage screenings, in comparison with other fuels, have a low fuel value varying with moisture content from 4000 to 6000 B.T.Us. dry-basis value.

As a basis for calculation of cost of auxiliary fuel to be used, the following figures may be used: Fuel oil at 3c per gal. or $1.30 per bbl., coal at $4.75 per ton, and natural gas at 20c per 1000 cu. ft., actual heat units are obtained for 50,000 B.T.Us. for 1c.

It is interesting to analyze the problem of burning refuse of a special type in accordance with the thermal values involved. Assume refuse of 60% moisture and a 4000-B.T.U. content and a furnace efficiency of 33 1/3%. One ton of refuse would equal 1200 lb. of water and 800 lb. of dry fuel. Latent heat of water vaporization is 970 B.T.U. per lb. plus heat to raise to 212 deg., equals 1100 heat units required per lb. of water, or 1,320,000 heat units per ton of refuse. 800 lb. of fuel at 4000 B.T.U. $\times$ 33 1/3% Efficiency = 1,060,000 B.T.Us. afforded or less than the necessary amount of fuel to provide evaporation and combustion.

Extensive heat losses must be considered, of which furnace absorption and radiation are considerable. To avoid nuisance or offensive odors, gases of combustion and vapors must be subjected to 1200 to 1800 deg. temperature in the combustion chamber. This treatment will result in great convection losses.

This analysis emphasizes the necessity for reducing the water

content wherever possible and by whatever processes may be available. This is especially important in the case of incineration of sewage screenings or sludge where the water content is very high and the fuel content and value very low.

One ton of 2000 lb. at 95% water equals 100 lb. of dry fuel and 1900 lb. of water. If the water can be reduced to 65% by mechanical processes, then 1700 lb. of water has been removed, leaving but 190 lb. to be evaporated per ton of refuse instead of the 1900 lb. in the original condition. Here additional fuel will be required, as only 100 lb. of dry-basis fuel was present. If oil of 17,000 B.T.U. content is used to supply heat, a single arithmetical calculation will indicate how much oil and consequent cost for fuel will be required.

To meet the problem of burning intractible, low grade water-soaked fuels has given rise to innumerable variations in design and practice. Hundreds of patents have been taken out covering every conceivable phase, and to describe them would be a long story. The impressive lesson is that the problem is not simple, as is evidenced by the long search for an approximate answer.

Since proposals for sewage screenigs disposal plants have generally been from established incinerator firms, brief descriptions will be given of a few of the typical plants in common use as indicative of the types available.

England for many years has been constructing well-designed furnaces, sorting rubbish, and utilizing heat from combustion as far as possible by steam production. The furnaces in general use are of the Sterling, Heenan, or Meldrum type.

There is another rather strictly American type of crematory that deserves special attention. This is the inside-storage type, with several representativs at th present, and has had several more in the past which are not now in general use. The Nye Odorless, Superior, Decarie, and FredSmith fairly represent this type. These crematories have a great deal to be said in their favor, the principal advantage being economy of operation. The ample space provided, which allows garbage to be dumped from trucks directly inside, eliminates plant handling and economizes on operating costs. Naturally, however, it is more difficult to control temperature and to maintain it above the desirable minimum of 1200 deg. considered most favorable for furnace practice.

There are a greater number of crematories of this type than the European or English type in America. Where the location is not critical, or where mixed refuse containing a high percentage of combustible is to be burned, or where rubbish alone is to be burned, this type of crematory possesses considerable advantages in ease and economy of operation.

An interesting type is the Morse Boulger—it does not depend upon grates but rather upon brick arches to support the refuse, and long flame-travel and an ample combustion chamber are provided. Furnace temperature is under good control. Thus, while temperatures

above 1200 deg. are maintained at the stack base, high temperatures (1800 to 2200 deg.) are avoided. Thereby, production of excessive amount of clinker is avoided, which facilitates ash removal.

For purposes of illustration, some fundamental data will be considered.

Water-Evaporation

It 1 lb. of water in screenings at 60. deg. temperature is to be converted into steam at 800 deg. there would be required 152 + 972 + (588 × 0.48) = 1406 B.T.U.

Air-Requirement

In order that combustion may be complete and no carbon monoxide be emitted, air must be supplied in considerable excess. If 20% excess air demand is allowed (this is very low and likely to run up to 100% or more), 17 lb. of air per pound of oil will be used. This means that 18 lb. of flue gases for each pound of oil burned will require to be heated to the temperature of escaping gases.

Oil and Fuel Requirement

Oil at 19,000 B.T.U. per pound has a heat content of 147,000 B.T.U. per gal. of 7.7 lb. This will yield 18 × 7.7 = 138.6 lb. of flue gas per gal. of oil.

Now, if the oil and air enters the furnace at about 60 deg. and leaves it at 900 deg., there will be absorbed 138.6 × 840 × 0.24, or 27,942 B.T.U.

Thus there is available from 1 gal. of oil 147,000 — 27,942 or 119,058 B.T.U. to be expended in evaporation of moisture; raising the temperature of oils, and supplying furnace radiation. Likewise, if chimney temperature is 1250 deg., the available heat will be 107,416 B.T.U. per gal. of oil.

One ton of wet screenings containing 90% water, dewatered to contain 80% water, still contains 45% of the original water, or 810 lb. per ton of raw screenings. Thus, 50 tons of screenings per day will contain 40,500 lb. of water to be handled through the furnace. If this is raised (to assure safety from odors) to 1250 deg. temperature, the heat required is 152 + 972 + 1038 × 0.48, or 1622 B.T.U. per pound of moisture. A daily load of 40,500 lb. of water will demand 65,691,000 B.T.U. supply, or 610 gal. of oil at 107,416 B.T.U. per gal.

Another Illustration

Sewage screenings pressed to 70% moisture content.
Heat analysis—70% moisture
5% sand
25% dry fuel at 6000 B.T.U. value

0.70 lb. water 62 × 212 = 150	
0.70 × 150	105 B.T.U.
0.70 lb. water at 212 (latent heat of vaporization = 971)	
0.70 × 971	678 B.T.U.
0.70 lb. steam from 212 to 1412	
sp. heat steam at 0.48	
0.70 × 0.48 × 1200	403 B.T.U.
$.25 lb. dry combustible (gases) raise 1200	
sp. heat gases at 0.24	
0.25 × 0.24 × 1200	72 B.T.U.
0.25 lb. × 18 combustible air raised 1200	
sp. ht. air = 0.24	
0.25 × 0.24 — 18 × 1200	1296 B.T.U.
0.05 lb. sand and ash raise 1200	
sp. ht. Si0 0.18	
0.05 × 0.18 × 1200	11 B.T.U.
Total heat required	2565 B.T.U.

Total heat available from dry combustible of 6600 B.T.U. value
0.25 × 6000 ..... 1650 B.T.U.

Deficiency to be supplied by fuel oil ..... 915 B.T.U.
0.051 lb. oil at 18,000 B.T.U. per pound contains ..... 918 B.T.U.
of 70% screenings. This equals 102 lb. fuel oil per ton. This equals 13 gal. oil per ton.
At 3c per gal. for oil, the cost is 39c per ton of 70% screenings.

In this analysis no consideration is given to the losses due to radiation. Also, in actual practice a greater amount of air than that assumed will probably find its way into the furnace. This will raise the temperature several hundred degrees and thereby demand more thermal units to supply the deficiency due to radiation and stack losses. Under the conditions referred to, 1200 B.T.U. shortage may well be expected.

The above analysis is given not so much to explain what does or does not occur in any given instance as to emphasize the fact that combustion itself is an exact chemical process wherein physical and chemical laws prevail. To a considerable degree of accuracy this process is capable of analysis.

The following table gives the estimated heat balance for the Los Angeles screenings incinerator now in course of erection:

HEAT BALANCE FOR LOS ANGELES
Data given in specifications
50 tons of screenings

Moisture	85%
Ash (dry basis)	9%
Heat value solids 8000 B.T.U./lb.	
Aver. exit gas temp.	1400° F.
Heat per gal. oil, 147,000 B.T.U.	

WET FINE SCREENINGS AND DEWATERED
Other data assumed

Temperature of screenings, air, oil	60° F.
Aver. exit gas temp.	1400° F.
Sp. ht. air and flue gases (dry)	0.24
Sp. ht. steam in flue gases	0.48
Sp. ht. ash	0.14
lb. of air required per lb. combustible	0.23
lb. of air required per lb. oil (20% excess)	0.17

TO DETERMINE WEIGHT AFTER DEWATERING

50T × 0.85 = 42.5 T. water
× 0.15 = 7.5 T. dry solids
If dewatered to 70%, dry solids equal 30%

$$\frac{7.5}{0.3} = 25 \text{ tons}$$

at 60%, dry solids equal 40%

$$\frac{7.5}{0.4} = 18.75 \text{ tons}$$

RESUME—DEWATERING 50 TONS OF SCREENINGS

Original Moisture	70%	66.7%	60% final
85%	25T	27.5T	18.75T
88	20	18	15
90	16.67	15	12.5

HEAT BALANCE, 1 TON AT 70% MOISTURE

2000 × 0.70 = 1400 lb. water
2000 × 0.91 × 0.30 = 546 lb. combustible
2000 × 0.09 × 0.30 = 54 lb. ash

	B.T.U.
Water 60° to 212° — 1400 × 152	= 212,500
Water to steam at 212 1400 × 972	=1,362,000
Steam 212° to 1400° = 1400 × 1188 × 0.48	= 797,000
Dry gases 60 to 1400 — 24 × 546 × 1340 × 0.24	=4,220,000
Ash 60° to 1400° — 54 × 1340 × 0.19	= 13,200
Radiation	200,000
Total heat required	6,804,700
Heat available 600 × 8000	4,800,000
Heat required from oil	2,004,700

HEAT BALANCE, 1 TON AT 85% MOISTURE

2000 × 0.85 = 1700 lb. water
2000 × 0.81 × 0.15 = 273 lb. combustible
2000 × 0.09 × 0.15 = 27 lb. ash

	B.T.U.
1700 × 152	= 258,000
1700 × 972	=1,652,000
1700 × 1188 × 0.48	= 970,000
24 × 273 × 1340 × 0.24	=2,110,000
27 × 1340 × 0.19	= 6,600
	200,000
	5,196,600
300 × 8000	=2,400,000
	2,796,600

Heat per gal. of oil	147,000
Heat in products of combustion of 1 gal. — 7.7 × 18 × 1340 × 0.24	44,600
Heat available	102,400

$\frac{2{,}604{,}700}{102{,}400} = 19.6$ gal. per ton

19.6 × 25 = 490 gal. per day

@ 3c per gal. = $14.75 per day

$\frac{2{,}796{,}600}{102{,}400} = 27.3$ gal. per ton

27.3 × 50 = 1365 gal per day

@ 3c per gal. = $40.95 per day

This illustrates the importance of an adequate dewatering system.

The Milwaukee incinerator was recently put in operation. H. W. Lincoln, engineer for Morse, Boulger Co., has given me the results of the test run made to determine capacity and operating efficiency as follows:

MILWAUKEE SEWAGE PLANT INCINERATOR

Rated capacity: 1667 lb. per hour. 20 tons in 24 hours.
Specified materials after dewatering: Coarse screenings, 7.7%; fine screenings, 57.7%; grit, 34.6%.
Average moisture content in mixture: 65%.
Guaranteed oil (150,000 B.T.U. per gal. at 60° F.): 12.5 gal. per hour; 15 gal. per ton.

8-hour Test

Material burned	6.77 tons	
Rate per 24 hours	20.3 tons	
Coarse screenings	7.0%	
Fine screenings	38.5%	Proportions estimated on wet basis
Grit	54.5%	
Total oil metered	75.9 gals.	
Oil burned per hour (as metered)	9.5 gals.	

(Oil 26.2° A.P.I. 144,240 B.T.U. per gal. 150° aver. temp.)
Oil per hour (corrected for temperature and heat content): 8.77 gal.
Coarse screenings (aver. five samples): 76.2% moisture, 15.19% ash (dry basis).
Fine screenings and grit (aver. nine samples): 58.53% moisture, 26.55% ash (dry basis).

Operation of the Milwaukee plant will be watched with interest, as it will afford considerable reliable data concerning which there is a great lack at the present time.

There is one very noticeable characteristic which causes a good deal of concern with reference to screenings incineration, namely the sand problem. In the Milwaukee plant, the sand content was 50% the weight of the screenings. Pressure in the furnace from this amount of mineral not only adds a load to be handled, but also affords a menace to furnace maintenance. This requires that the furnace temperature should be under good control in order that the fusion of the silica on grates and firebrick lining may not be a source of heavy depreciation. Also, if temperatures are allowed to run above 1800 to 2200 deg., large production of clinker will result.

The above analyses have indicated that reduction of the moisture content of screenings is very important.

To appreciate this statement another illustration will be made: If 1 ton wet sludge of 95% moisture could be dewatered to 65%, thereby 90% of the water is removed, or 1710 lb. per ton. To evaporate this water from 62 and at 212 deg. alone requires 1126 B.T.U. per pound, or 1,925,460 B.T.Us. at 100% efficiency. At an efficiency of 2/3 and at 5,000,000 B.T.Us. per dollar, the cost for fuel in reducing the screenings to 65% moisture, where its heat content under proper furnace conditions will carry on to complete combustion, will be 51c per ton of wet sludge.

This theoretical illustration compares very well with dehydration practice in industry, where a figure of a cost of 50c per ton of water evaporated is often used. Since water removal is an important part of this problem, the methods available therefor should be considered. Mechanically, there appear to be four methods available—centrifuge type, cider-press type, rolls, and filtration. The practice here is none too well standardized. I will leave the discussion of this matter to others.

Some may contend that the discussion is based on considerations and refinements altogether unwarranted in disposal of such a crude material as screenings or sludge. For most small cities, disposal of screenings is not a very difficult matter, but if sludge is to be handled in ten times greater quantity the problem does assume considerable magnitude.

There is another phase of the problem that has not been touched upon and that is odors. This phase is often quite serious, and the incinerator operation (unless it is properly designed and operated) may only aggravate the situation. An incinerator burning at a uniform rate and maintaining a combustion-chamber temperature always above 1250 deg. or dark red heat will emit no offensive furnace odors. The plant should include a good chimney, ample in size and height. This itself should be a valuable asset to the entire sewage treatment plant. The grit chamber and the rag picker may be housed and ventilated into the chimney. It will no doubt be necessary to do the same for the rolls or press room, where septic sewage is being handled. The chimney will afford an opportunity to care for any odor problem that may arise.

The fuel problem may be met when sludge digestion is practiced by using gas from digesters. Here there is an interesting possibility, as it may continue to be economical to carry sludge digestion to a point where it can be dewatered by filtration methods. This will afford a gas supply that may be adequate for auxiliary fuel purposes, but I will leave this phase of the problem to be discussed by the next speaker. It would appear that digestion and dehydration may be adjusted to a very nice balance.

I recognize that this discussion has been to some extent based upon theoretical considerations as far as application to screening incineration is concerned. A year from now, F. A. Batty or J. H. Van Norman may be able to give actual operating data on this interesting and important subject.

INCINERATION OF SLUDGE

By R. F. GOUDEY*

Screenings and fresh sludges on a dry basis have one-half to one-third the heat value of fuel oil. It is little wonder, therefore, that many attempts have been made here and abroad to utilize it. Liquid sludges require more heat to evaporate contained moisture than can be supplied by their solid contents. This has led to many experiments with such admixtures as refuse, oil, coke, coal, resin, sawdust, and other materials. The reason for renewed interest in sludge incineration follows recent successes in dewatering sludges to the point where incineration can be carried on with the heat value of the contained solids. In cases where dewatered sludges are valueless as fertilizers, the process of dewatering and incineration constitutes an easy, reasonable, convenient, and unobjectionable method of sludge disposal.

Each sludge has to be studied by itself. Its volume, water content, amount of volatile solids, and B.T.U. value must be determined. These items vary widely for different types of sludges, as is indicated in the following table:

SLUDGE INCINERATION FOR ONE M.G.D. OF SEWAGE
SOUTHERN CALIFORNIA CONDITIONS

Type	% Eff. S.S.	Gal.	% H_2O	Lb. dry	B.T.U. (dry) available		B.T.U./ gal. for evapo-ration	Dil cost wet sludge	Dewatered-incinerated	
					Per lb. dry	Per gal. sewage			% water	Total cost
Screened	10+	220	85	275	7500	1.9	2.0	.....	83	.....
Fresh	75+	2450	92	1630	8500	13.8	22.8	$5.00	60	$1.75
Digested no activated	75+	2050	93	1200	2500	3.0	19.1	$4.15	72	$3.65
Fresh-activated undigested	98+	4050	93.5	2200	7500	16.5	37.8	$8.20	65	$2.50
Fresh-activated digested	98+	2910	94	1460	2000	2.9	27.2	$5.90	72	$4.60

It is noted that:

1. Sludges with activated sludge present, whether fresh or digested, are more liquid than fresh or digested sludges.

2. Digestion, particularly when followed by air or sand-bed drying, depreciates the B.T.U. value of sludges from 30 to 80%. This reduction varies almost directly with the amount of volatile matter remaining. Drying alone may reduce volatile solids more than digestion accomplishes.

3. While there is about four times the available heat in fresh sludges over digested sludges, the added B.T.U. requirement for evaporating their waters is only 10 to 37% greater than for digested sludges, depending upon the ratio of activated sludge contained in them.

4. If incineration is carried on without preliminary dewatering, then incineration of digested sludges is cheaper than their corresponding fresh sludges. This,

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as well as the next paragraph, does not assume any value from gas developed in the digestion process, nor does it include comparisons of fixed or operation charges for digesters.

5. If incineration is applied to dewatered sludges, then the opposite is true; namely, that the combined chemical and incineration cost for fresh sludges is about half that for digested sludges.

6. The chemical cost of dewatering fresh and excess activated sludge to 72% water followed by incineration is about $2.50 per m.g. The addition of liberal allowances for labor, power, maintenance, and depreciation still keeps the cost of incineration within attractive limits.

7. The B.T.U. values assumed for fresh sludges are admittedly low. Sludges direct from digesters may contain about 4500 B.T.U., but upon drying over half of this value appears to be lost. The tabulations for digested sludge may be too conservative, but the comparisons are still interesting and should not be taken as an argument to do away with digesters.

From a graphic comparison of the oil cost for incineration between fresh and digested sludges for different moisture contents, digested sludge dried to 44% is comparable with fresh sludge at 86%. The corresponding values for the same sludges containing excess activated sludge are 55% and 85%, respectively. This comparison also does not take into account the utilization of gas from the digester or any fixed and operation charges other than that of oil.

Some work has been done by different firms in using spray-drying equipment to reduce the water contents to the point where incineration can be effected at low temperatures. The principle is that of atomizing the sludge to produce enormous surface exposures, which accelerates drying. By this method liquid sludges can be reduced from 90% to 10% in one operation at a cost of about $5.00 per m.g. The problem of successfully atomizing solids contained in fresh sludge cannot be said to have been solved. It appears that using the spray-drying process for dewatering sludges with water contents greater than 90% is not practical, but below this value it may have an edge on chemical methods of dewatering.

Sludge incineration is a field which has been given but little attention, at least so far as applied to present-day sludges of different types, and it appears as if the subject warrants further consideration.

ROSTER OF MEMBERS

California Sewage Works Association

For names and addresses of C.S.W.A. members see 'Sewage Works Journal', Vol. V, No. 2, p. 369-74, published by the National Federation of Sewage Works Associations at Easton, Pa. As of July 14 the California Sewage Works Association had 212 paid-up members.

CROSS-CONNECTIONS BETWEEN WATER AND SEWAGE SYSTEMS

By RAY L. DERBY*

The title of this paper at first glance perhaps may seem far-fetched. The existence of cross-connections between hygienically safe supplies and those of questionable purity has long been known, and public health officials have been urging their elimination for years with considerable degree of success. Why, then, should it be necessary to speak of such an obviously dangerous practice as cross-connections between sewers and water systems when the lesser evil is already under curtailment?

The reason for this is two-fold. In the first place, an actual physical connection permitting water to flow in either direction readily is of infrequent occurrence, and when it does exist the much higher pressure in the water main is depended upon to prevent a reversal of flow from sewer to water main. That this difference in pressure cannot always be relied upon for protection is shown by the occurrence of many outbreaks of intestinal disorders, some reaching epidemic proportions.

A second type of cross-connection is that in which ordinarily no direct connection exists but, due to stoppage in the sewer causing sewage to back up, the water supply may be reached, either directly or by creation of a negative head in the water main causing siphonic action. This type of connection has likewise taken its toll in outbreaks of intestinal diseases.

Examples of cross-connections of the direct type are confined chiefly to the priming connections of sewage pumps and to the sludge-breaking pipe in the sludge compartment of Imhoff tanks. Priming connections are exceptionally dangerous, as the failure of an employee to close or open the proper valve, or the failure of the valve itself, might allow raw sewage to be pumped directly into the water mains. Just such an occurrence took place in Chicago in 1927 when an employee in a power plant neglected to close the priming valve before starting his pumps, and over 100 cases of intestinal disorders were reported. Connections should either be prevented or else protected, at least by double check valves.

The sludge-breaking line to Imhoff tanks is not so dangerous, since pollution could only reach the water main by siphonic action in case of negative pressure in the main and a leaky valve at the tank. In some cases protection by check valve or a vacuum breaker may be secured.

By far the greatest number of cross-connections are included in the second category, that is, where the stoppage of the sewer will

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cause backing up of sewage and either submergence of a water connection permitting siphoning in case of negative pressure in the main, or else direct flow of sewage to main, well, or reservoir.

Two outstanding examples of this kind are the Santa Ana typhoid epidemic of 1924 and the South Pasadena dysentery epidemic shortly thereafter. In the former case a drain from a pump pit connected with an old abandoned sewer. During heavy rains the sewage backed up the sewer into the pump pit and finally into the well, thereby entering the system. In the South Pasadena case no physical contact took place. A leaky sewer crossed underneath a riveted steel gravity line which, in turn, became pitted from sewer gases. The sewage backed up and ran directly into the gravity line feeding the pump sump.

Reservoir drains and overflows may be a potential source of pollution also. A low reservoir, a leaky drain valve, and the sewer or storm drain under a head from stoppage or flood waters may readily cause pollution of the supply.

Flush tanks, due to stopping of sewer and negative head in the water main, may siphon sewage into the water systems.

A further source of possible contamination, not often considered, is the ordinary plumbing fixtures of the home, hotel, hospital, office building, and the like. These may be placed in two classes, viz., those with constantly submerged inlets when in good operating condition, and those whose inlets may be submerged if stoppage or backing up of wastes occurs.

In the first class are siphon jets and flush valves in toilets, steam tables, some types of bath tubs, swimming pools, instrument sterilizers, etc. In any of this class, a vacuum formed in the water main would cause polluted water to be siphoned into the pure water system, even if there was no obstruction in the sewer line. This type of connection should always have a vacuum breaker installed as well as check valve for protection. Standard practice in the Los Angeles Water Department is to eliminate such types of connections entirely.

In those fixtures with outlets not normally submerged are the ordinary flushing rim-opening toilets, bath tubs, lavatories, slop sinks, dish-washing machines, etc. With this type, the coincidence of stoppage of the sewer with leaky valve and a vacuum in the water main must occur to permit contamination of the supply. As such conditions are not beyond the bounds of probability, provision should be made for vacuum breakers and check valves. The safest method in all cases is to have the inlet, wherever possible, entirely above the maximum possible point to which backed-up sewage could occur.

There are many other examples of possible cross-connections between water and sewage systems, but in the time allotted I have endeavored to point out the prevalence of such connections and mention some of those most frequently encountered. A thorough review of engineering literature will reveal many more.

CROSS-CONNECTIONS BETWEEN WATER AND SEWAGE SYSTEMS

By C. W. SOPP*

This subject has heretofore been presented at water and sewage works conferences and has been especially well presented by the preceding speakers. From the invitation to speak I conclude that the experience and attitude of a waterworks man is desired, and also what Pasadena is doing in this problem.

Cross-connections in plumbing have been defined by the American Society of Sanitary Engineers as "any construction or system whereby it is possible and/or probable, that a potable water supply may be contaminated".

Contamination from cross-connections may be one of the principal causes of the occurrence of a poorer quality of water at the tap than at the source.

The installation and operation of a water system has a large influence in causing indirect cross-connections through the draining or siphoning of plumbing fixtures.

Direct cross-connection in piping may be made by connecting to the wrong line, or by hose connection from a water line for priming sewage pumps. As an example, the water supply for a school cafeteria was contaminated by tapping a circulating water line of the swimming pool. Considering sewage pumps, if the pressure in a pump exceeds that in the water supply, and the connecting-hose valve is opened, sewage will be pumped into the water system. Complete reliance cannot be made on check valves for protection. This direct type of cross-connection is quite apparent and inexcusable.

Indirect cross-connections may occur through plumbing fixtures. Flooded inlet fixtures will cause contamination by direct drainage, neglecting siphon action, if the water supply line has been drained and the inlet valve is opened. The draining of a water supply line creates a vacuum in the absence of large air inlets, and causes a siphon action which will drain certain fixtures, even though the inlet is above the water level. In some cases the current of air passing over a water surface and entering a draining supply pipe will pick up large quantities of water in the form of a mist. This type of cross-connection is not readily apparent and should be carefully investigated.

Conditions incident to contamination are generally a temporary fall of water pressure, or complete shutoff of water supply either in a service or water main. A fall in water pressure may be due to low initial pressure and a heavy draft, or small pipes and a heavy draft. I have observed the pressure on a 1½-in. and 1-in. supply pipe fall from 80 to 25 lb. during the flushing of one direct-flush toilet, while in another case temporary vacuum was caused by heavy draft in other parts of a building.

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A complete shutoff of the water supply either in the service or water mains, and draining of the pipes, will cause a partial vacuum in the water supply pipes. This vacuum will drain under rim supply fixtures where the inlet is flooded and a valve opened. It will also siphon the contents from many fixtures where there is a closed or semi-closed connection, even though the supply is from above.

One of the worst offenders is the direct flush toilet through flushometer valves. Most of these valves require positive pressure to close them, and any valve which opens on a negative pressure is almost certain to permit siphoning and to remove the entire contents of a toilet bowl. In some types of flushometer valves, siphoning only occurs through the small bypass and a flooded toilet is required; the water level in the bowl will recede to the rim and then the entering air will prevent further siphoning. In some similar installations, the under-rim air supply is insufficient to break the vacuum, and siphon action will continue until the toilet bowl is emptied. This action will occur in side, back, and top-inlet, siphon-jet, and other types of bowls.

Walter Putnam, superintendent of buildings, and J. B. Davis, plumbing inspector for the city of Pasadena, tested a large number of flush valves and toilet bowls. A glass tail-piece between the valve and bowl permitted observation of the action of air currents in lifting water in the form of mist or films. These tests revealed that nearly all types of flushometer valves will permit siphoning either through the opening of the valve under a vacuum or through the bypass. They also showed the almost complete failure of certain types of air inlets, air breaks, and check valves to prevent siphon action under normal working conditions. As a result of their tests, only one make of flushometer valve is approved for installation in the city of Pasadena.

Under normal operation, small mains or small pipes in services and buildings will give an inadequate supply; this condition is aggravated where coupled with low pressures. Under these circumstances the flushing of a fixture on a lower floor may give negative pressures and cause the draining and siphoning of fixtures on higher floors.

The normal operation of a plumber shutting off a service and draining the pipes may cause a vacuum which will drain and siphon fixtures into the supply pipes. When the supply is restored, contaminated water will be distributed throughout the premises.

The main sizes and pressures should be adequate to prevent large drafts by fire engines pulling a vacuum in mains.

The normal operation of shutting off mains and draining for making connections, or the abnormal condition of main breaks and repairs will give partial vacuums and negative pressures on supply lines. The Pasadena Water Department has made a number of tests of the vacuums that may exist in mains due to draining. The degree of vacuum is dependent on the size of main, grade, and the rate of draining and admission of air. The opening of valves and fire plugs in a draining main allows air to replace the draining water and limits the vacum. The tests were on mains 4 to 16-in. diameter and 410 to

1175 ft. long, using recording gages. Partial vacuums quickly develop from 57 to 88% of the maximum possible. A 5-in. vacuum remained on a 16-in. main 1 hour after the shutoff. The attached table gives results of these tests.

In one main test on a steep grade, with no service connection to allow admission of air, a vacuum of 28 in. was created by draining. This is about the worst condition to be met, but it is one to be guarded against.

Pasadena has created a Plumbing Fixture Board, composed of the health officer, superintendent of buildings, and the chief engineer of the Water Department. The board approves or rejects any plumbing fixtures, or restricts the use or manner of installation of any fixture so as to prevent cross-connections. This action has even had the effect of architects in surrounding communities specifying fixtures approved by Pasadena.

1933 SAN LUIS OBISPO SPRING CONFERENCE PAPERS

Published in the Journal of the National Federation of Sewage Works Associations and in Western Construction News and Highways Builder. These papers are not included in the current C.S.W.A. Journal.

'History of Chemical Precipitation', by Leon B. Reynolds, professor of sanitary and hydraulic engineering, Stanford University. Sewage Works Journal, Vol. V, No. 4, July 1933.

'Palo Alto Experiences in Chemical Purification of Sewage'*, by Ralph A. Stevenson, sanitary engineer, Great Western Electro-Chemical Co., San Francisco. Western Construction News and Highways Builder, Vol. VIII, No. 13, July 1933.

'Recent Developments in the Chemical Treatment of Sewage in the United States Outside of California', by Charles Gilman Hyde, professor of sanitary and hydraulic engineering, University of California, Berkeley. Sewage Works Journal, Vol. V, No. 5, September 1933.

'Incineration of Skimmings', by A. P. Banta, assistant engineer, Los Angeles County Sanitation Districts. Sewage Works Journal, Vol. V, No. 4, July 1933.

'Detection and Measurement of Certain Types of Gases', by S. H. Ash, engineer, U. S. Bureau of Mines, Berkeley. Sewage Works Journal, Vol. V, No. 4, July 1933.

'Hazardous Gases in Sewer Manholes, Gas Masks, and First Aid'*, by C. H. Fry, safety engineer, California State Industrial Accident Commission, Sacramento. Western Construction News and Highways Builder, Vol. VIII, No. 14, August 1933.

'Design of Gas-Collection Systems for Sewage Works'*, by T. R. Haseltine, superintendent, Salinas Sewage Treatment Plant. Western Construction News and Highways Builder, Vol. VIII, No. 15, September 1933.

* These papers will be reprinted and sent by the California Sewage Works Association to each of its members. It is suggested that the reprints be saved and inserted in the Journal.

HAZARDS, GAS MASKS, AND FIRST AID

By FRED D. BOWLUS*

Sewer gas annually takes the lives of several engineers and workmen, and explosions cause large financial losses. Only last year, two California engineers were killed in sewers, and hundreds of thousands of dollars' damage was done in Montreal, Canada.

Men of ordinary courage go about their daily tasks in other dangerous occupations, such as the erection of tall buildings and high bridges. Iron workers face the furnace blasts and white-hot bars of the rolling mills, and sailors cling to the yard arms of windjammers, confident that they can avoid injury by their own care and skill. Their dangers are visible to the eye. In the case of sewer maintenance and several other occupations—mining, for instance—a workman of equal courage encounters a tremendous handicap in combating invisible gases. Loyalty to his superior causes him to do the assigned tasks directed by the man in charge. He cannot himself cope with this intangible danger, but must depend on the judgment of his superior, who is supposed to be informed.

The responsibility of the engineer, or superintendent, is great when workmen are exposed to invisible gases. My experience during the past 5 years directing the operation and maintenance of the Los Angeles County Sanitation Districts' trunk line sewer system has emphasized this fact. In ignorance of the lurking dangers of this unseen foe, too many chances were taken at first, until one day I was entirely overcome for several minutes in a sewer and owe my life entirely to the heroic efforts of two workmen. Experience, training, and the most improved gas detectors have subsequently made possible the handling of difficult situations such as were encountered in the inspection and repair of sewer lines, after the recent earthquake, when hundreds of gallons of gasoline were dumped into the system from the bursting of mains and tanks and gas-main leaks.

Although much study has been given to the composition of liquids flowing in a sewer system, only meager information is available regarding the gases above the sewage within the structures. Loss of life is so often attributed to the presence of hydrogen sulphide gas, whereas other gases might be the real cause.

Gases originate in a sewer from the sewage itself and from leaks in nearby gas, gasoline, and other utility lines. Air in sewers carrying fresh domestic sewage is comparatively pure, because the water carrier ordinarily contains sufficient dissolved oxygen. After flowing through the sewer for a few hours, the sewage goes through a biological reduction process and oxygen depletion occurs in the overlying air. At Boston, Jones & Perrot found methane, carbon-dioxide, and small quantities of hydro-carbon gases in sewer gas. Hydrogen sulphide is often generated. In quiet air methane, being only half as

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heavy as air, will be found at the top of the sewer. Carbon dioxide, half again as heavy as air, will be found immediately above the sewage.

When industrial wastes are added, other gases may be formed. Gasoline and other petroleum products admitted to the sewers cause explosive mixtures in the structure above the sewage. Temperature and velocity of the sewage, siphons, and other obstructions in the sewer are important factors in liberation of gasoline vapor. Vapor pressure of the gasoline is another item.

Results of tests made by Burrell & Boyd at Pittsburgh show that 55 gal. of gasoline dumped into a sewer manhole at one time caused no great hazard when the sewage had a high velocity. The 8-ft. sewer, 0.5 mi. long, had sufficient grade to give the sewage a velocity of 6.45 ft. per sec. Although 70% of the entire pipe-line would have been filled with gasoline vapor, had all of the gasoline turned to gas, tests revealed that only one manhole had a mixture of over 2%, and smaller percentages were found in other manholes. After 10 minutes, no dangerous condition prevailed. A subsequent test with the outlet submerged and the introduction of but 5 gal. of gasoline, showed an extremely dangerous gas mixture throughout the length of the structure for a long period. The time of detention seemed to be the important factor.

Explosive mixtures of gasoline vapor and air vary from 1.4 to 6%. Gasoline vapor is about three times as heavy as air, hence is found immediately above the sewage.

Natural or manufactured gas finds its way into the sewage from gas-main leaks, located either within sewer structures or adjacent to them. Since it is rare that gas mains are permitted to pass through sewer structures, most of this gas finds its way into the sewer through leaks in structures. Most gas contains large percentages of methane and hydrogen, with small quantities of carbon monoxide, carbon dioxide, nitrogen, and hydrogen sulphide. Tests show that methane passes through the ground more easily than the hydrogen and carbon monoxide.

Of the gases found in sewers, carbon monoxide, hydrogen sulphide and gasoline vapors are toxic for men to breathe. Carbon dioxide and nitrogen in moderate percentages cause only temporary asphyxiation. Gasoline, methane, and other hydro-carbons are explosive in certain concentrations. The following table shows the general characteristics of gases usually found in sewers.

Gas	Sp. gr.	Normal % in air	Tolerable %	Signs of distress %	Probable death %	Explosive range %
Carbon monoxide, CO	0.97	.....	0.02	0.06	0.40	.....
Hydrogen sulphide, H_2S	1.19	.....	0.005	0.05	0.10	.....
Oxygen, O	1.11	20.9	12	8 to 10	5 to 6	.....
Nitrogen, N	0.97	79.0	.....	.....	.....	.....
Carbon dioxide, CO_2	1.53	0.03	3	3 to 5	18	.....
Methane, CH_4	0.56	.....	.....	.....	.....	7.1 to 16.7
Gasoline	.....	.....	0.5	1.0	2.3	1.4 to 6.0

Protection is afforded men working under such conditions by the use of two types of gas masks. One has a long hose leading to a supply of fresh air, and the other uses a filter or reactive medium in a canister which either adsorbs or neutralizes the offensive gases. Each type of mask has its advantages. The canister type can be used only in moderate concentrations of gas, while the hose type is adaptable to larger percentages. A high concentration of ammonia gas causes a skin irritation, for which the masks afford no protection. Canisters for protection against organic gases such as benzine, or gasoline, contain activated carbon; those for acid gases, such as chlorine, hydrogen sulphide, and carbon dioxide, use caustic soda fused on pumice. Canisters are also supplied for protection against both types of gases, while a special one protects against carbon monoxide.

The canister type is probably the best mask for all-around use in a sewer—provided it contains the right chemicals—because the wearer can proceed farther from the source of fresh air than with the hose type. However, the latter are particularly adapted to inspections in high concentrations of gas within a short distance of a manhole. Laborers doing heavy work experience difficulty in obtaining sufficient air, even with a 25-ft. length of hose. It has been found that a man uses eight times as much oxygen walking at a rate of 5 mi. per hour than standing still, and correspondingly exhales eight times as much carbon dioxide.

Since many gases have no odor, detector instruments have been developed during the past few years. Such an apparatus indicates the presence of two toxic gases, hydrogen sulphide and carbon monoxide, the deficiency of oxygen, and the explosion percentage of a gas. The tester weighs 16 lb. strapped to a man. Much can be learned from a survey of a sewer system by the diligent use of this instrument.

Knowlton has reported very satisfactory results from the use of a similar detector indicating only explosive gas in the sewer system of the city of Los Angeles. In 1500 manholes tested, he found the air to be dangerous in 21% of them. The Los Angeles County Sanitation Districts have one of the latest types of detectors and many interesting observations have been made from tests in the trunk sewers. Gases emanating directly from the sewage have a tendency to be uniformly distributed along a sewer line, increasing in concentration along the line of travel. Ether gases, however, may remain localized in short lengths of line and may not be discernible at even short distances from the point of entry.

Hydrogen sulphide and carbon monoxide are usually found in any sewer where the sewage is retained sufficiently long to become septic. The County Sanitation Districts are practicing chlorination along sewer lines to control odors at the treatment works and prevent bacterial decomposition. With such practice the maximum hydrogen sulphide found in the sewage is 3 p.p.m., but tests so far have failed to indicate the presence of hydrogen sulphide or carbon monoxide in the air in any of the sewers.

Aside from manholes adjacent to gas-main leaks, no explosive mixtures are found except along the 10-mi. section of the joint outfall sewer immediately above the sewage treatment plant. This section, ranging from 5¼ to 10½ ft. diameter, has always shown combustible mixtures at some points, and occasionally these were explosive. The most explosive occurred where the sewage was turbulent, leading to the belief that the gases were liberated thereat. Men working at these points would be quickly overcome if they were not supplied with fresh air from a blower.

In a 10-minute test, a man with a gas mask using a canister as protection against acid gases was not affected by the sewer gases; without a mask he was partially overcome in 5 minutes. The gas-detector set indicated the absence of hydrogen sulphide and carbon monoxide gas, but showed that it was 60% explosive. The oxygen-deficiency lamp showed a depletion of about 16%. It is concluded from these tests that organic gases, such as methane and gasoline vapors, had no toxic effect. The reverse was true, however, with acid gases. The sewage carried no chlorine residual and had no hydrogen sulphide. Considerable quantities of carbon dioxide are formed in the early stages of sewage decomposition and it was tentatively concluded that this gas is the offender. Further laboratory tests are to be made of the gases for additional proof of this statement.

Carbon dioxide, about 40 times more soluble in water than oxygen, is also as easily liberated. This gas generated would readily be dissolved above and liberated at points where turbulence occurs. There is no dissolved oxygen in the sewage itself in the joint outfall section, hence the depletion of oxygen in the air. Methane gas is only slightly more soluble in water than oxygen, and it is unlikely that sewage in passing a gas main leaking into the sewer would absorb any appreciable amount of this gas and carry it into a lower point in the sewer. Methane is present in the large sewers, but probably due to its generation in the sewage. Through the use of suitable gas masks, Sanitation District employees required to enter the sewers are amply protected even though air in the structures is partially depleted.

The Schafer prone-pressure method of resuscitation, as ordinarily used in cases of drowning and electrical shocks, is recommended for sewer gas victims, with the use of additional oxygen, if possible, in monoxide cases. First-aid kits should always be available for workmen.

The Sixth Annual C.S.W.A. Convention will be held at Santa Cruz, September 18 and 19, 1933; headquarters, Palomar Hotel. Recent announcement by the new federal Public Works Administrator that water works and sewerage projects will receive first preference for loans under the National Industrial Recovery Act, forecasts a revival of sanitary engineering construction. Come to Santa Cruz and participate in the convention proceedings.

CHANGES IN THE CHARACTER OF SEWAGE

By F. S. CURRIE*

Sewage, as far as its water content is concerned, is purer than the well-known Ivory soap. Yet, there is no other single substance in the engineering profession that is as changeable, unreliable, ornery, and messy as sewage. This three or four-tenths of one per cent of solids which constitute the impurities in sewage can contain body wastes, household wastes, community wastes, street washings, by-products of industries, tons of rags, and, in fact, everything from raincoats to the kitchen stove.

To present a paper on the changes in character of anything which so obviously has no character is somewhat similar to writing an article on the width of a line.

Changes in the character of sewage are as varied as the localities in which it originates, as the hours in the day, the days in the week, and the seasons in the year, and in turn depends on them. The price of domestic water in a community, as well as the nationality of the people and the types of industry, all have their effect on the character of its sewage wastes. However, regardless of its origin, the actual change in the character of a particular sewage depends upon the time elapsed between its source and the point of disposal. My guess would be that the change varies at least as the square of the time.

One of the most recent examples of the change in sewage that has come to my attention is at Signal Hill, California, where we have recently completed a treatment plant consisting of Imhoff tanks, trickling filters, secondary sedimentation, and final sand filtration through pressure filters. The effluent is stored in a 40,000-gal. reservoir and pumped to the refineries to be used in their boilers and cooling towers. As there is no outlet to the plant other than this pressure line, the effluent must at all times be of such a nature that it will not foam or scale.

Ninety per cent of the sewage has been pumped three times through a total lift of 160 ft. Naturally it is pretty well chewed up and the storage in three pump pits and pressure lines does not help any. Besides this, only a few families immediately connected to the sewer, which did not provide enough food for proper seeding of the trickling filter or digestion chamber. A couple of oil companies, however, did make connections, and provided plenty of food for thought.

The real problem is the elimination of drill mud which has been either dumped into the sewer lines or is deposited in old sewers which have laid unused for the past 4 years. I have never seen anything just like it. It will not settle and we haven't until recently been able to remove it in the pressure filters. About the only place that one can actually depend on its removal is in a boiler.

Various coagulents have been tried at practically every possible point in the treatment. Alum and lime in the pots immediately pre-

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ceding the pressure filters did not prove successful, as there was insufficient time for floccing before filtration. Ferric chloride and sodium aluminate were also tried at this point. The ferric chloride was a total failure, but fairly good results were obtained with the sodium aluminate. The feed now consists of alum in a manhole about 200 ft. above the plant, lime immediately ahead of the secondary clarifier, and sodium aluminate in the pots of the pressure filters.

Experiments with a model flocculator show wonderful results with either ferric chloride, or alum with activated carbon, but we feel that eventually the source of the drill mud will be eliminated and the construction of a flocculation basin would not be warranted.

In my experience the most radical change in the character of a sewage was not attributable to any of the reasons mentioned previously in this paper, but to a development in a method of manufacture.

In 1924 we were employed to design outfall sewers and disposal works for the city of Corona, California, replacing an old septice tank that had been in use for several years. Tests showed nothing out of the ordinary or difficult in the domestic sewage, except that because of the comparatively high water rate it was quite concentrated. However, the city was blessed with an industry known as the Exchange Lemon Products Co., which at that time was only extracting the citric acid from the cull and excess lemons of the Sunkist Exchange of Southern California. The location of the company could, and still can be, picked out by its bouquet. It was the one nose sore of the town, and naturally it was necessary to include the disposal of these wastes in the general program.

The staff of the company included several very competent chemists and we immediately imposed upon them to give us an analysis of the waste we would have to handle, as well as the average and maximum future flows. At that time the pulp of the lemon was being used as feed for cattle, and also as fertilizer for the orange groves in the vicinity, and it was explained that it would not be necessary for us to provide for its disposal.

The liquid was clear and amber-colored and the analysis showed no settleable and little if any suspended solids. Solids in solutions amounted to 2300 p.p.m.; sulphates, 400 p.p.m., and a b.o.d. of 640 p.p.m. The waste was sterile, having been boiled and treated with sulphuric acid in the process of extracting the citric acid. Samples were also taken of the sand beds, upon which the waste had been spread for the past 3 years. These showed the sand to be fairly clean and still serviceable as a filter. We were also informed that the flow at that time amounted to 150,000 g.p.d. and that a plant with a capacity of 250,000 g.p.d. would be sufficient to handle the waste for 10 years to come.

Considering the above data we decided that under no circumstances should this waste and the domestic sewage be handled together. Separate lines of sewers were constructed to the plant site and separate methods of disposal were planned and built.

The domestic sewage is treated in Imhoff tanks and trickling filters, designed for a population of 10,000 and costing $43,500.

It was decided to treat the by-products waste on intermittent sand filters, with no primary sedimentation, anticipating a future maximum flow of 300,000 g.p.d. Six beds, each with an area of 0.6 acre, were constructed on the natural sand of the plant site. No underdrainage was provided. These beds were dosed from a single dosing chamber through six alternating siphons.

For 6 or 8 months everything functioned almost too well. Then one of the aforesaid competent chemists discovered that the company had been overlooking a big bet all these years in not extracting the pectin as well as the citric acid from the lemons. It was such a good idea that the growers found they could make more money out of their lemons through the by-products company than on the then low lemon market, and on one particular day 50 carloads of lemons were put through the plant.

The waste flow immediately jumped to 600,000 g.p.d. and contained most of the pulp and peel of the lemons. The piping to the alternating siphons plugged up and the filter beds were all full and running over. It required about 2 weeks for a bed to drain and thoroughly dry, after which the pulp could be removed in large sheets about ¼-in. thick resembling felt.

The city gave up in despair and the by-products company took over operation of the filter beds, which have been increased to five or six times their original number. The beds are now filled, allowed to dry, and the pulp is removed and burned.

The officials of the company realize that the present waste has no resemblance to analyses given to the city and upon which the plant was designed. They are operating the filter beds at their own expense and can well afford to, as the increased revenue due to the production of pectin more than compensates them.

Daily changes in the character of sewage from the Decker Packing plant at Mason City, Iowa, necessitated the abandonment of their activated sludge plant and the construction of a more flexible type, including washable trickling filters.

Changes in character of sewage, as far as the biological and chemical changes that take place in the sewer lines, can be controlled to a great extent by the use of chlorine or air. Changes due to developments in industry can and should be controlled by compelling each industry to treat its own wastes to such an extent that it will compare favorably with domestic sewage.

Sewer-revenue bond laws were considered by the last state legislatures of California, Colorado, Idaho, Montana, Oregon, and Washington and approved with the exceptions of Colorado and Washington. New Mexico previously had such legislation on its statutes.

CHANGES IN CHARACTER OF SEWAGE

By W. C. ROBERTS*

In order to avoid duplication of information given in other papers on this subject, the following remarks are restricted to observations and laboratory analyses which have been made at plants designed in the office of Clyde C. Kennedy.

Unfortunately, much of my information is based on observation and not enough on laboratory data. With the exception of the Phoenix activated sludge plant, none of the plants have accumulated any laboratory data on raw sewage. At most of the plants the pH of the digestion units is taken and orthotolidine tests are made if chlorination is used, but beyond these two essential tests no other routine tests are run.

The seasonal differences that are commonly observed in almost all sewages are: increased flow during the rainy season, seasonal temperature changes, more odor during the summer months, and changes due to trade wastes from seasonal industries such as canneries. Other changes less commonly found are usually caused by one or more of these more general changes, or are variations of them. However, there was an exception to this at Dunsmuir, which occurred when the city was metered. The metering resulted in a decrease in the sewage flow from about 800,000 g.p.d. to 300,000 g.p.d.

The effect of the fresh fruit season is not only noticed in trade wastes, but also in purely domestic sewages. At Reno, large amounts of peach and apricot pits were collected in the desritor during the season for these fruits. At the Marin Sanitary District plant in San Anselmo, there are large quantities of grape pulp and skins during the wine-making season.

The seasonal changes in temperature of sewage seems to have more effect on its characteristics than any other one thing. One example of this is the increased growth of the group of Fungi, of which the Spaerotilus is typical, during the colder months of the year. At Dunsmuir the bar screen would clog up several times a day and the matted growth in the bottom of the primary clarifier prevented normal operation. Dosage of lime above the outfall line controlled the growth fairly well. The same thing also occurs at Sparks, Nevada. C. C. Taylor, city engineer of Sparks, reports that during January, February, and March, when he is troubled with this growth, the pH of his digester increases noticeably.

Perhaps the most important effect of changing sewage temperatures is the effect on the physical and chemical composition of the sewage. This is particularly noticeable in the case of sewage solids. The slower bacterial activity in cold weather results in increased settleable and suspended solids. This is partly explained by decreased activity of gas formers, as they have a marked effect in the

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breaking up of sewage solids. The following table shows the effect of temperature changes on solids at Phoenix and gives an average of daily tests.

	Aver. temp. raw sewage	Cu. ft. m.g.d. screenings bar screen	Susp. solids p.p.m.	Set. solids c.c. liter
August and September	85	2.8	134	2.2
December and January	69	5.7	177	4.4

With a temperature difference of 16° F. the cold months show that the screenings and settleable solids are doubled and the suspended solids increased 32%. The b.o.d. for this period increased 5% and the total flow decreased 9%.

Chemical changes in the sewage for these months were also found at Phoenix. The cold months showing an increase in nitrites, nitrates, ammonia, and a decrease in sulphides. These changes are summarized as follows:

	Total sulfides p.p.m.	Nitrites p.p.m.	Nitrates p.p.m.	Ammonia p.p.m.
August and September	0.7	0.2	0	4.7
December and January	0	0.36	0.87	14.8

These changes are accompanied by no appreciable change in the pH or in the chlorine demand.

I have no data showing noticeable monthly sewage changes, the tendency being to follow the seasonal changes.

Weekly sewage changes commonly observed are volume changes due to low flows on Sundays and holidays, and high flows during portions of Monday and Tuesday due to water from home laundries. A study of the analyses of the Phoenix plant does not show any appreciable changes in solids or b.o.d. for the different days of the week, as the flows seem to vary with the solids. There is a change noticeable in purely domestic sewage from small towns or at institutional plants; these show high b.o.d. and solids on Monday and Tuesday and low tests for Sunday.

The changes in sewage are greater during each 24 hours than are the seasonal changes. These changes are found in the whole range of sewage tests. In purely domestic sewages I have found daily variations in b.o.d. of from 30 p.p.m. to 1200 p.p.m., settleable solids from a trace to 15 c.c. per liter, and suspended solids from 40 p.p.m. to 1500 p.p.m. Sewage flows under normal conditions may increase 50 to 1000%, usually depending on the amount of normal infiltration, greatest changes being noticed with a minimum of infiltration. Where trade wastes occur these changes are even greater. For some trade wastes such as milk wastes the b.o.d increases rapidly without a corresponding increase in settleable or suspended solids. For other trade wastes the reverse may be true.

Where trade wastes occur, the b.o.d. and solid increases may show but little correlation with changes in the volume of sewage flow. For domestic sewages—especially for smaller communities—there is general correlation. The limited number of tests which I have made on these sewages usually show a lag of 1 to 2 hours of the b.o.d. and

solid peak behind the flow peak. This lag is in general proportional to the age of the sewage when it reaches the plant.

In the study of sewages from different communities we have found considerable variation in the sharpness of the peak and in the time of its occurrence.

For institutional plants, such as the one at Montezuma School at Los Gatos, there are several peaks and great variation in both volume and chemical characteristics. This sewage has changed from a practically pure water to one with a b.o.d. of over 700 p.p.m. within half an hour.

For small communities with a purely domestic flow, such as Morgan Hill and Soledad, the daily peaks are fairly uniform as to time but are quite marked. The night and early morning flows are very low both in flow and solids. The night flows will show a b.o.d. of 30 p.p.m. or below. The daily peak may go as high as 600 p.p.m., but only for a short time, usually dropping rapidly and with other peaks after the lunch and dinner hours.

For larger communities such as San Anselmo and Roseville, the night flow is proportionately greater and a higher b.o.d. of about 60 is found. Daily peaks are broader and there is less change in the b.o.d. and suspended solids during the day. As a rule the flow rises rapidly in the morning and falls gradually, with intermediate peaks showing luncheon and dinner loads.

For still larger cities such as Phoenix the night flow may show a b.o.d. of 100, but usually is about the same as for smaller cities, although of shorter duration. The morning peak rises fairly rapidly, but is very broad, usually falling slowly for about 15 hours and then with a more rapid drop to the minimum flow. There are seldom any peaks during the day, such as shown by smaller cities. The b.o.d. and suspended solids do not form sharp peaks, but are fairly uniform after the first rapid morning rise until late in the evening. They are as a rule more uniform than the rate of sewage flow.

From the standpoint of the designing engineer, the daily changes in sewage flow and chemical characteristics are of great importance. However, it is interesting to note the seasonal change, which is very seldom considered either in design or in operation. The accumulation of more information on these seasonal changes, particularly from smaller communities, would be very desirable.

Sewerage facilities of California cities, towns, and sanitation districts, as surveyed in 1930-32 by the Bureau of Sanitary Engineering, State Department of Public Health, have been compiled and published privately in a convenient statistical form, price $2.50. Further information may be obtained through the Bureau.

KEEPING DOWN POWER COSTS

By H. K. PALMER*

Economy in power costs, whether of water, air, or sewage, is a factor of plant design, but efficient operation will have a very marked effect on these costs. Each plant is a separate problem, calling for careful analysis. The proper design of a pumping station is not restricted to the efficiency of machinery and equipment placed in the plant, but relates to the plant as a whole, with the selection of equipment best adapted to the work that is to be done.

A common mistake is the use of inlet and outlet pipes of a size the same as the suction and discharge connections on a pump. The velocity of water through centrifugal pumps is more than 12 ft. per second. Such velocity will cause excessive friction in inlet and outlet pipes which are too small. A 25% increase in the diameter of pipe is sufficient to reduce the friction by two-thirds. In the average plant this reduction of friction would actually amount to about 5 ft. lift. The theoretical power required to lift 1 m.g. of water 1 ft. is 3.14 kw.-hr. With efficiencies of pumps and motors as ordinarily obtainable, it would actually require about 6 kw-hr. to do the work, so that with a loss of a 5-ft. head due to piping that is too small, it would be possible to waste 30 kw.-hr. for every million gallons of sewage pumped.

The force main should be large enough to provide for maximum flows, and should be larger than the station piping. The designer should not make the main so large that the interest on the increased cost would be more than the saving of reduced power charge, nor so large as to reduce the velocity of flow and increase the detention time in the pipe to such an extent as to cause sewage to become septic.

The size of the force main is fixed by the maximum pump capacity, rather than by the maximum sewage flow. Because of the variably flow of sewage, it is usually handled by a single pump running intermittently, or by one pump running continuously with a second pump cutting in when required.

The minimum size of pump desirable for pumping sewage is about 4 in. to avoid clogging, and because the efficiency of a small pump is less than that of a large one. In many cases it is desirable to have two pumps, each of a capacity slightly larger than the average flow, so that one pump will handle the flow for the major part of the time and the second pump need be started only for more or less short intervals. Thus, when the maximum flow exceeds 1200 g.p.m. and the friction head is 15% of the total head, it will pay to use two 1000-gal. pumps rather than a single 2000-gal. pump. With such an arrangement most of the sewage or water will be pumped by a single pump against a low head and both pumps, developing a higher head, will be required only to handle the peak flow.

* Chief Draftsman, Los Angeles County Sanitation Districts.

The friction head increases as the square of the flow so that, with two or more pumps operating in parallel, the lift is greater than for a single pump. But, since the increased lift reduces the flow of each pump, the friction head developed by the two pumps will not be so great as four times the friction head due to one pump. As an illustration, where the combined capacity of the two pumps is 50% greater than that of one pump, and the maximum flow is 0.9 the capacity of the two, 78% of the daily flow will be handled by the single pump and only 22% by both of them together. Often the saving will be greater than this, but the possibility depends upon the amount of flow, pump size, and pipe-line friction.

Regardless of the size, an extra pump should be provided as a standby in case of breakdown or to handle emergency flows and on account of friction in the force main, three smaller pumps will handle only slightly less water than two larger pumps. At the outset, installation of smaller pumps will permit of future development in growing systems and will save investment and interest charges thereon.

Pumping plants sometimes have to serve more territory and larger flows than originally intended, and pumps have to be added. In this case, a second force main should be added paralleling the old one, if the saving in power will justify the cost.

An important use of power in sewage disposal is aeration in an activated-sludge plant. It is not in the province of this paper to consider the relative merits of compressed air and mechanical aeration, but considered merely from the standpoint of mechanical stirring, the compressed-air method is very wasteful of power. However, the addition of air under pressure is an advantage and lessens the mechanical stirring required. There is a patented system which permits air to be introduced at about half the depth of the tanks. This permits the use of smaller air pressure, with a corresponding saving in power, but the air is in contact with the water a shorter time and more may be required. Such an arrangement will not reduce the power required by one-half, for the pressure loss in the diffuser will remain the same.

Air diffusers should be kept as free from obstruction as possible, as it is very easy to waste a pound or more of pressure when it becomes clogged, and every pound of pressure calls for about 75 kw.-hr. per million cubic feet of free air, or in terms of compressor capacity, 110 kw.-hr. per day for each 100 c.f.m.

In plants where gas can be collected from the digestion tanks, it might be used in gas engines to develop power to supplement purchased power (1 b-hp. should be developed with about 15 cu. ft. of sludge gas of 666 B.T.U. per cu. ft. (W. B. Walraven—Sewage Works Journal, Vol. 4, p. 614, July 1932). Thus, 22½ cu. ft. of gas would yield 1 kw.-hr. on the switchboard. This power could be utilized directly, or to operate a generator to supplement commercial electric power. An easy way to do this would be to drive an induction motor above synchronous speed, acting as a generator. This has the dis-

advantage of being useless if outside power fails, but requires less attention than a generator. If local conditions and costs warrant, gas could be stored so it could be used to smooth out the peak, thus holding down the maximum demand and improving the load factor. The heat from the exhaust gases and cooling water of the gas engine can be used to heat the digestion tanks, so that all the gas can be used to produce power without sacrificing the heating possibilities.

Probably as important as any other factor is the maintenance of as constant demand of power as possible, usually referred to as a high load factor. Nearly all companies give a better rate for electric service if the load factor is high, because the power company is not required to provide such a standby service in larger installations. Every advantage should be taken of the high load factor and in the operation of the plant an effort should be made to use auxiliary motors when the larger motors are off the line. The lower the maximum demand of power, as indicated by the maximum-demand meter, the better the rate per kw.-hr. The effect of a high power factor and other savings affecting the efficiency of electric equipment has been given in another paper and will not be discussed here.

ASSEMBLY BILL NO. 980

(California Sewer-Revenue Bond Act)

Introduced by Hon. James B. Utt, Assemblyman from Orange county, before the California State Assembly January 25, 1933. Referred to the Committee on Public Health and Quarantine. Amended in Assembly March 31, April 10, and April 17. Amended in Senate April 29, May 1, and May 8. Passed and signed by the Governor as an urgency measure and now in effect. (See analysis by Clyde C. Kennedy on p. 7 of this issue.)

Title—"An act to provide for the acquisition, construction, extension and operation of systems and works for the collection, treatment, purification and disposal of sewage by cities, counties, sanitary and sanitation districts; also providing for the issuance and sale of revenue bonds to the Reconstruction Finance Corp. or other fiscal agency of the United States to pay for the acquisition and construction of such works, which bonds shall be payable exclusively from the revenues derived from the operation of such works; also providing for the establishment and collection of service rates or charges to pay for the expense of constructing, operating, and maintaining such works; also providing for the use of such works by other cities, counties or districts, and declaring the urgency thereof."

TAX DELINQUENCIES IN SANITARY DISTRICTS IN CALIFORNIA

By C. R. COMPTON*

Sanitary districts in California, as in the case of other special tax districts, are faced with increasing tax delinquencies to such a degree that in some cases the operation of sewage treatment plants and works has practically stopped, with resulting damage to plant and equipment. The present general financial condition of the country is probably the greatest cause of such tax delinquencies; but to a certain extent these delinquencies may also be laid to the particular type of district and, in some cases, to over promotion on the part of ambitious community developers.

The increase in delinquencies is of concern to many public officials and sanitrians. There are at present 43 active and two inactive sanitary districts in California. The districts are principally along or near the coast, from the San Francisco Bay region to San Diego. There are districts as far inland as Folsom, Victorville, and Indio. Twenty-one of these districts do not require sewage plant operation, but depend on dilution in tidal waters. This method is used almost exclusively around San Francisco Bay region and along the coast where tidal waters may be reached economically. Eleven have Imhoff tanks, eight have septic tanks and three have sedimentation with separate sludge digestion. A few of the Imhoff-tank plants have trickling filters. The 45 districts serve a connected population of some 56,000 persons, with 60,580 tributary to the various systems.

In Los Angeles county there are eight sanitation districts having a population of 440,000, with 241,000 connected.

The first Sanitary District Act was passed by the State legislature in March 1891; was first amended in 1895; and again by every legislature from 1901 to 1911; and was known as the Sanitary District Act of 1891. In 1919 another act, known as the Sanitary District Act of 1919, became law. This act provided that districts formed under the act of 1891 could reform under this act. In 1923 a third act, known as the Sanitary District Act of 1923, was adopted. This act permitted districts previously created under the 1891 Act and the 1919 Act to be reformed under the provisions of the 1923 Act. Advantage was taken of this feature of the act by several districts, and also many new districts have been created under it. The 1923 Act is the one now most generally used for new districts.

All of the Sanitary District Acts are the same in principle. They provide that the districts shall be governed by an elected sanitary board of five members who, by recent legislation, serve 4 years, and provide for a tax assessor, who is also elective and serves 2 years. The county tax collector collects the taxes for such districts, the county treasurer is the treasurer, and the district attorney may act as counsel. Each act has provided that the tax rate for operation and maintenance purposes shall not be greater than 15c on each $100 of assessed valuation. The principal difference between the several acts relates to the bonds. The 1891 Act permits a bond life of 25 years, with interest not to exceed 5%; while the 1919 and 1923 Acts permit a bond life of 20 years, with interest at 6%. The 1891 Act limits the bonded indebtedness to $75,000, while the 1919 and 1923 Acts permit bonds to the extent of 15% of the assessed valuation of the district.

Each of the acts has provided a type of district well suited in general for accomplishing the objects in view, the principal idea being to establish as nearly as possible a self-contained and self-governed unit.

Another act, the County Sanitation District Act of 1923, became law in 1923, and under its provisions the districts in Los Angeles county have been created. This act provides for the government of a district by the presiding officers of the governing bodies of the municipalities within a district. The county auditor is the auditor of a district and the county treasurer is the treasurer. Most important is that the tax valuations of the county assessor are used in fixing the tax rates.

* Office Engineer, Los Angeles County Sanitation Districts.

While it would appear in the sanitary districts that the limitations on the tax rate for operation and maintenance purposes, and a limitation of the amount of bonds that can be issued are ample safeguards against promiscuous spending of the districts' money, these provisions can be easily evaded by an increase of property value by the district assessor. In some cases the assessed valuation of sanitary districts is as much as six times greater than that used for general county purposes, but only in a very few cases is at as low.

Since each district is, as a rule, a more or less self-contained community, the result has been that all have had their particular problems to deal with. In some of the districts where only the direct-dilution method of disposal is used, the costs have been low, with the result that the delinquency in district taxes have been low also. However, in a great number of districts where greater construction and operation costs have been necessary, due to local conditions demanding a high type of treatment, the tax delinquencies have been as high as 18 to 20%, and in one instance as high at 50%.

In one case, with a community development far below that anticipated at the time the system was constructed, the sewage flow was so small as to increase the detention period in the plant, with the result of hydrogen sulphide generation and the like, which played havoc with steelwork, machinery, and equipment. With the community development smaller than was expected, the tax load upon the actual community was much greater than was anticipated, which in turn created a high tax delinquency. With high tax delinquency and increased repair bills, it was impossible to prevent deterioration of the plant, and it was actually necessary to by-pass the small amount of sewage around it.

The conclusions to be arrived at are that while the delinquency in sanitary districts has increased at a rapid rate, it probably is no greater than that for other small districts, and that as general financial conditions improve, district conditions will improve. Also, that the particular type of district, not only as to law, but as to the economic structure, have been contributing factors to delinquency. The districts, as a rule, are small and are not in position to work out their solutions jointly, but must carry the entire burden themselves. Where the costs have been low, no great problems have arisen, but where more expensive methods of disposal are necessary, the costs have been out of proportion to the ability of the district to carry the load and trouble has resulted.

It may be that the recent sewer rental legislation will be of benefit to the various sanitary districts. However, this is new legislation and its effect can only be determined by use.

TAX DELINQUENCIES IN SANITARY DISTRICTS

By D. E. PERRY*

In Sanitary District No. 1, Marin County, we have about 6700 lots, pieces, or parcels of assessable land; improved and unimproved. Our total assessable value in 1932 was $6,700,000, which means average assessments of $1000 each. Our taxing powers are limited to a 15c per $100 rate, for running expenses, operating as we do under the 1919 Sanitary District Act. Our original bond issue, contracted in 1921, was for $200,000, covering the cost of a 6½ mi. trunk line, varying in size from 10 to 30 in., and a treatment plant. The trunk line cost us $165,000 and the treatment plant $35,000. We have retired one-quarter of this bond issue to date; the interest on this issue was 6%. We have never, so far, defaulted in any of our payments, although annually, for the past several years, we have had an increasing tax delinquency.

We have been allowing soldiers' exemptions, annually for the past years, to the extent of $325,000 to $350,000; church exemptions to the amount of $90,000; and we have been getting no revenues from schools, college, orphanages, municipal

* Assessor and Manager, Sanitary District No. 1, Marin County, San Anselmo.

buildings, such as town halls, fire halls, libraries, etc. Likewise, we have been getting no revenues from other utilities, such as railroads, gas, electric, water, etc. As banks and these utilities do not pay local taxes, we have no way of securing revenue, unless a sewer-rental act or some similar provision is made available.

Several months ago, the attorney general's office notified us that we should have been taxing the soldiers and these others, just the same as the other taxpayers. The decisions of the attorney general were issued in the cases of Ripon Sanitary District vs. Bank of America, on June 12, 1929, in a communication to G. C. Darrah, district attorney, San Joaquin County; one to the district attorney of Sonoma County, under date of October 31, 1927; and one to me on November 9, 1932. The substance of these decisions is that veterans and others must pay for sanitary sewer service, as "exemptions do not extend to improvement or special-benefit assessments". As banks, utilities, such as railroads, etc., do not pay county or city taxes, this means that assessors for sanitary districts must assess and place values on the property of such, within the bounds of the sanitary districts. This makes a difficult job for assessors.

Our tax rate for bond interest and redemption is 21c per $100. This, with the 15c running expense rate, makes a total tax rate of 36c per $100. Our bond issue was for 40 years; retiring only $5000 per year, and as stated, we have now retired $50,000 to date.

Delinquencies all over the state have become a problem; our have run as follows:

Year	Total Delinquency	Cost of Adv.
1925	$ 803.18	$224.00
1927	698.05	279.00
1928	1052.00	300.00
1929	1315.33	406.00
1930-31	1748.70	530.00
1931-32	2312.29	800.00

This Sanitary District received from regular taxation, during the past several years, about $10,200 for running expenses. We pay about $800 per year for power for operating pumps at the treatment plant. Our power rate is 3.5c for the first 750 kw.-hr. and 2c for the next units. Our Board expenses are $300 per year. The secretary to the board receives $360 per year. Our expenses for assessing, writing up assessment rolls, purchasing these rolls, writing up tax bills, printing the same, etc., absorbs about $800 of our running-expense revenues. Hence, the cost of advertising this annually-increasing delinquent tax list has become a problem.

As the 1919 Act permits the board to make such arrangements as it may please, respecting the collection of delinquent sanitary taxes, our board this year may not publish the delinquent tax list at all. The average bill amounts to less than $3, one-third of which belongs to the running expense account and two-thirds to the bond account. No portion of the expenses can be charged to the bond fund, and the redemptions, during the past few years, have not kept pace with the new delinquencies. Eventually these must come in, although we have many lots in the poorer sections of the district on which no taxes have been paid for as many as 6 years. Nothing has been done toward taking these properties from the record owners. We find that when county taxes are cleared up, our district delinquencies are cared for at the same time.

The average contribution toward the running expenses of our district is less than 12c per month. This includes everything and amounts to less than the price of a shoe-shine or a soft drink. If citizens got as good a run from other branches of their government as they get for their meager contributions toward sanitary sewer service, there would be less of a howl about exorbitant taxation.

Municipally-owned utilities, such as water systems, gas, electric and phone systems, collect from schools, churches, public buildings, orphanages, libraries, etc. However, sanitary districts have been in the habit of giving free service, especially

when districts get their revenue on the ad valorem basis called taxes. The attorney general says these contributions are not taxes but service charges. As such, these departments of the government have been getting off without contributing revenues to specially-created districts, rendering this special service by reason of the fact that they pay no taxes and there is no other means of measuring the value of the service rendered than this obsolete ad valorem system.

Veterans do not get free service from municipally-owned utilities, other than sanitary ones, and it is expected that there will be much kicking this year when districts refuse to allow the usual $1000 exemption. As banks, railroads, express companies, etc., do not pay local town or county taxes, they too will now have to contribute to sanitary district revenue. It is expected that the schools, junior colleges, etc., will likely refuse to contribute, as they have never paid in the past and there would appear to be no way of enforcing payments from such bodies, except cutting off the service. That might create a bitter sentiment against such districts.

The answer to those opposing payment, according to the attorney general, is: "These contributions are not taxes—they are service charges. It may be generally said that a tax is levied for the general public good without special regard to the benefit conferred upon the individual or upon property subject thereto, while a special assessment is levied to force payment for a benefit equal in value to the amount thereof. It is a charge on specific property for a specific purpose, founded upon the benefits supposed to be derived by the property itself".

Many assessors do not access automobiles, money, credits, etc., for sanitary district purposes. Assessors may, under the 1919 Act, lower assessments against properties not fully served by the sewer system, or even exempt the same, if they are not benefited by the system. The attorney general says, in one of these decisions: "If all of the property in the district is uniformly assessed, it may be classed as a tax, but if anything less than all, or a certain kind of property is charged, it is an assessment and not a tax, and yet the charge may be an assessment though it is imposed on all property in the district".

TAX DELINQUENCIES IN SANITARY DISTRICTS

By G. C. ZUCKWEILER*

Tax delinquencies in sanitary districts ultimately become very serious to those representing the district, and the sanitary boards are unable to carry out their duties prescribed by law. There is perhaps no one subject worthy of deeper study or of greater importance than that of the formation of sanitary districts. Careful consideration should be given to the district within its boundaries, the type of disposal plant to be erected, and its cost of operation and maintenance.

San Diego county has three sanitary districts, known as Kensington Park, Vista, and Carlsbad. Kensington Park Sanitary District had 11% delinquent taxes for 1932. A greater amount of the delinquent taxes was caused by the tax collector's office in issuing bills only for state and county taxes, and not the sanitary district tax bill. This has been corrected by the sanitary board. This district has never suffered from delinquent taxes and has always met its obligations. The district covers 120 ac., has 300 sewer connections, and serves about 3000 people.

Due to the fact that some of the sewer lines had to be laid on a very flat grade so that the trunk line could be connected to the San Diego city sewer, it was necessary to install flush tanks—33 in all—for use twice a year. The cost of water to flush the sewers is an added expense to the district. The operating expense, including assessing of district, cost of sanitary district election, upkeep of sewers and flushing, amounts to $700 a year.

The Vista District had 24% delinquent taxes in 1932, covers 450 acres, has 150

* Chief, Division of Sanitation, San Diego County Health Department.

sewer connections, and serves about 750 people. Careful consideration was given to the formation of this district, committees were appointed by various civic organizations for the betterment of their sanitation, and after much study the sanitary district was formed. Some difficulty was encountered in obtaining a site for the disposal plant, but these were overcome and the present site was selected, which is an ideal location for the plant. The type of plant selected has functioned efficiently at a very low cost, with the result that when the district was confronted with delinquent taxes it could still meet obligations and continue to function in a proper and sanitary manner. The operating expense, including assessing the district, cost of sanitary district election, upkeep of sewers and disposal plant, is $800 a year. This district has a very fine and efficient disposal plant. The treatment plant maintenance and operation cost is about $28 a month.

Carlsbad Sanitary District had 25% delinquent taxes in 1932. The district covers 1640 ac., has 44 sewer connections, and serves about 250 people. The population served constitutes the business district and central part of the town. Operating expense, including assessing of district, cost of sanitary district election, upkeep of sewers and disposal plant, amounts to $2080 a year.

Carlsbad had outgrown its individual sewage disposal methods and was very much in need of a sewer system. The town was infested with cesspools which were overflowing, causing a very insanitary and unhealthy condition, and there was very little room to dig new cesspools. It was obviously important that this town should make other provisions for sewage disposal and the citizens of Carlsbad were assured by outside interests that if the town were sewered, extensive building would begin immediately. With this assurance, the sanitary district was formed. Its boundaries take in 1640 ac., with a widely scattered population. A modern, up-to-date disposal plant was built, which reached the point of extravagance with its many motors, pumps, patent clarifier, patent skimmers, digestor with patent agitator, chlorinator, and other mechanisms much too elaborate for the population served. Such a plant requires an operator qualified to run the plant in a safe and efficient manner, and if any of the phases mentioned should be omitted, it would impair the efficiency of the plant. Such a type of plant is very desirable for cities or large towns, but should not be attempted in small-populated sanitary districts such as Carlsbad, where a more simplified system could have been erected.

We are now having the unpleasant experience in Carlsbad of just such a plant. Those parties who promised to support the sanitary board are now among the heavy delinquent taxpayers, the delinquencies amounting to hundreds of dollars. Delinquent taxes and equipment at the disposal plant in need of repair has placed the sanitary board in a position where it was obliged to discontinue plant operation. At this writing, raw sewage is being bypassed around the plant into the outfall sewer and, to make matters worse, recent rains have washed out a portion of the outfall sewer. This results in solids being deposited on the beach, causing an insanitary and unhealthy condition.

When the district was confronted with delinquent taxes, an elaborate plant in need of repair, and many other expenses that could not be met, the sanitary board was placed in a very embarrassing position.

In comparing the districts, Kensington Park had 11% delinquent taxes in 1932. It covers 120 ac., has 300 sewer connections, serves 3000 people at a cost of $700 a year. Vista had 24% delinquent taxes in 1932, covers 450 ac., has 150 sewer connections, and serves 750 people at a cost of $800 a year. Carlsbad District had 25% delinquent taxes in 1932, which is 14% more than Kensington Park, and 1% more than Vista District. Carlsbad District covers 1640 ac., which is 1520 ac. more than Kensington District and 1198 ac. more than Vista. Carlsbad has 44 sewer connections, which is 156 less than Kensington Park District and 106 less than Vista District. Carlsbad District serves 250 people, which is 2750 less than Kensington and 200 less than Vista. Carlsbad District maintenance and operating expense is $2080 a year, which is $1380 more than Kensington District and $1280 more than Vista District.

In comparing the districts, it is very evident that if a sanitary board does not look to the future when creating a sanitary district, many unpleasant and expensive experiences may occur.

INDEX TO ADVERTISERS

American Concrete & Steel Pipe Co. ..... Inside back cover
Carborundum Co., The 152
Gladding, McBean & Co. 152
Great Western Electro-Chemical Co. ..... Inside front cover
Fairbanks, Morse & Co. 151
Pacific Clay Products 150
Pacific Flush Tank Co. ..... Inside back cover
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Wallace & Tiernan Co., Inc. ..... Outside back cover
Western Construction News and Highways Builder 151

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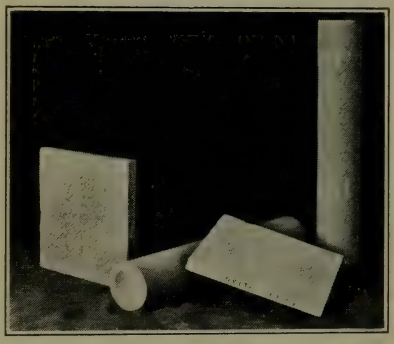

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Pelton ww – Bull #

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